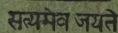


OF THE



Price : Rs. 4-6 or 7 sb.

TABLE OF CONTENTS

PART I.—REPORT OF THE DIRECTOR

	PAGE
1. INTRODUCTORY	1
2. SUMMARY OF MAIN RESULTS OF RESEARCH, 1953-54	3
GENERAL FEATURES OF THE REPORT—	
(i) Land and buildings	19
(ii) Post-graduate training	19
(iii) Library	20
(iv) Advisory work	20
(v) Research Schemes	20
(vi) Collections and Herbaria	22
(vii) Intensive Cultivation Scheme	23
(viii) Meetings and conferences	23
(ix) Supply of pedigree seeds and stocks	23
(x) Patents of Agricultural Machinery	24
(xi) Museum of Agricultural implements and organisation of a Tractor Testing Station	24
(xii) Visitors	24

PART II.—REPORTS OF THE HEADS OF DIVISIONS FOR 1953-54

1. Report of the Division of Agronomy including Agricultural Sub-station, Karnal	25
2. Report of the Division of Botany including Botanical Sub-station, Pusa	41
3. Report of the Division of Soil Science and Agricultural Chemistry	59
4. Report of the Division of Entomology	73
5. Report of the Division of Mycology and Plant Pathology	87
6. Report of the Division of Agricultural Engineering	101

PART III.—APPENDICES

I. List of Gazetted Staff of the Institute during 1953-54	113
II. Training of students and research workers during 1953-54	117
III. List of papers published during 1953-54	121

PART I.—REPORT OF THE DIRECTOR

1. (a) INTRODUCTORY

One of the new research activities of the Institute deserving a special mention at the outset has been brought about by the expansion in work relating to soils under an agreement between the Government of India and the American Technical Co-operation Mission. The main lines of work envisaged under this agreement have undoubtedly opened up a vista of potentialities of no mean value to the cause of Indian Agriculture. These comprise five items *viz.* (1) Soil Survey and Soil Mapping, (2) Development of a Rapid Soil Testing Service for drawing up manurial schedules, (3) Cartography, (4) Radio tracer investigations and the determination of the phosphorus status of Indian Soils by radio tracer methods and (5) Agronomic Trials for determining fertilizer responses in the 20 major soil types.

Another event which may be regarded as notable is the establishment of the Rust Research Laboratory at Simla which was formally declared open by Dr. Punjab Rao Deshmukh, Minister for Agriculture, on the 18th June, 1954. This synchronised with the release of the new wheat variety called N. P. 809 which was earlier evolved by the Sub-station of this Institute at Simla, combining resistance to the three rusts. This variety obtained by inter-crossing the hybrids resistant to individual rusts has been found under field conditions to withstand appreciably the three rusts, black, brown and yellow.

Besides being resistant to these diseases N. P. 809 has been found to be a heavy yielder in the hilly tracts of Punjab, Himachal Pradesh, U. P. and West Bengal. In many of the trials conducted in these regions it out-yielded the local varieties in a striking manner.

(b) LEAVE, TRANSFER AND POSTINGS OF GAZETTED STAFF

Dr. B. P. Pal, Director, was away from 26th June, 1954 to 26th July, 1954, on deputation as the leader of the delegation to the 8th International Congress of Botany held in Paris. Dr. T. J. Mirchandani, Head of the Division of Agronomy and Principal, Central College of Agriculture, held charge of the current duties of the post of the Director during the period.

Dr. R. S. Vasudeva, Head of the Division of Mycology, went on deputation to the United States of America on 19th June, 1953, which was completed on 30th August, 1953. On his way back to India he attended the 6th International Congress of Microbiology held in Rome from 6th to 10th September, 1953. He resumed his duties on 14th September, 1953. During his absence Dr. R. Prasada, Mycologist, Co-ordinated Wheat Rust Control Scheme and Dr. B. L. Chona, Systematic Mycologist, successively carried out the current duties of the post of the Head of the Division of Mycology—the former from 20th June, 1953 to 10th July, 1953 and the latter from 11th July, 1953 to 13th September, 1953.

Dr. Vasudeva was also deputed to attend the 5th Commonwealth Mycological Conference in London and the International Commission on Plant Disease Losses and the Phytopathological Section of the 8th International Botanical Congress in Paris. He was away from 26th June, 1954 to 15th August, 1954, for the purpose. Dr. B. L. Chona, Systematic Mycologist, carried out the current duties of the post of the Head of the Division of Mycology.

Dr. B. L. Chona, Systematic Mycologist, who went to the United States of America on deputation for higher training returned and resumed his duties on completion of the training on 11th July, 1954.

Dr. P. C. Raheja, Agronomist, who was on deputation to the United States of America for higher training, returned to duty on the afternoon of 9th November, 1953.

With effect from the same date (*i.e.*, afternoon of 9th November, 1953) Dr. Raheja was appointed to the post of Agronomist in the "T. C. A. Scheme for the determination of soil fertility and fertiliser use".

Dr. N. P. Datta, Agronomist, who was on deputation to the United States of America for higher training returned after completion of the training and reported for duty on 12th November, 1953.

With effect from the same date (12th November, 1953) Dr. Datta was appointed to the post of Soil Scientist in the "T. C. A. Scheme for the determination of soil fertility and fertiliser use".

Dr. Rattan Lal, Assistant Insect Physiologist, was on deputation to the United Kingdom for higher training in Insect Physiology under the Colombo Plan for one year from 29th August, 1953.

Shri L. M. Mathur, Assistant Soil Survey Officer, was on deputation to the United States of America for advanced training in Soil Fertility and Soil Science (cartography) under the Point-Four Programme with effect from 17th September, 1953.

Shri R. D. Verma, Assistant Agronomist, who was on deputation to the United States of America for higher training completed the training on 20th March, 1954. From 21st March, 1954, he proceeded on 2 years' leave out of India.

Dr. B. Ramamoorthy, Officiating Assistant Physical Chemist, was on deputation to the United Kingdom for higher training at the Macaulay Institute in the Department of Spectro-chemistry under the Colombo Plan for 6 months with effect from 1st May, 1954.

Shri V. S. Mani, Officiating Assistant Plant Physiologist, who was on deputation to the United States of America with effect from 23rd June, 1953, for training returned and resumed his duties on 31st December, 1953, on completion of the training.

Dr. S. M. Sikka was appointed as the Head of the Division of Botany from 18th May, 1954 (forenoon) and Dr. R. D. Asana who held the post of the Head of the Division of Botany on an officiating basis reverted to his substantive post of Plant Physiologist and Shri T. J. Malkani who held the post of Plant Physiologist *vice* Dr. Asana, reverted to his substantive post of Assistant Plant Physiologist and Shri V. S. Mani who officiated *vice* Shri Malkani reverted to his substantive post of Research Assistant.

(c) ACCOUNTS DURING 1953-54.

The total expenditure of the Institute and its Sub-stations at Karnal and Pusa during the financial year 1953-54 amounted to Rs. 26,21,130/- as under :—

	Rs.
I. (1) General expenditure on the Institute including the office of the Director, Irrigation, Power Supply, Gas Plant and Estate establishment.	5,29,951/-
(2) Division of Statistics	22,737/-
(3) Division of Chemistry	4,35,978 (a)
(4) Division of Mycology	1,99,658/-(b)
(5) Division of Entomology	2,08,261/-
(6) Division of Botany	3,42,299/-
(7) Division of Agronomy	3,67,691/-
(8) Division of Agricultural Engineering	1,60,806/-
(9) Division of Economics	6,578/-
(10) Central College of Agriculture	1,93,027/-
Total	24,66,986/-
II. <i>Experimental Farms</i> —	
(1) Agricultural Research Sub-station, Karnal	89,697/-
(2) Botanical Sub-station, Pusa	64,447/-
Total	1,54,144/-
Grand Total of I and II	26,21,130/-

2. SUMMARY OF MAIN RESULTS OF RESEARCH (1953-54)

AGRONOMY

A. Weather

There were 19.5 inches of rain during the monsoon period and 5.30 inches during winter. The rainfall during February and March, which was followed by a strong wind, caused extensive lodging in wheat, oats and barley and this led to a considerable reduction in the yields of these crops. The potato and berseem crops were adversely affected by severe frost during January.

B. Manurial Experiments

i. *Green Manuring*.—In a green manure experiment, it was found that green manuring with guar, sannhemp, cowpeas, soybean and dhaincha gives significantly higher yields in wheat than the application of no green manure. The relative merits of the different green manure crops were studied, but there were no significant differences. The effect of phosphate in conjunction with green manures was not significant. Sannhemp gave the best results when the crop was ploughed in after eight weeks.

(a) Includes expenditure on T. C. A. Schemes.

(b) Includes expenditure on Co-ordinated Wheat Rust Control Scheme.

ii. *Nitrogenous manures and fertilizers.*—Application of sodium nitrate and ammonium sulphate gave similar results in sugarcane and cotton, but calcium nitrate proved superior to sodium nitrate and ammonium sulphate in sugarcane. Experiments conducted with ammonium sulphate and F. Y. M. at different levels in wheat showed that the value of F. Y. M. lies between 20-25 per cent. of ammonium sulphate. In maize also, application of ammonium sulphate at 80 and 40 lb. N per acre gave significantly higher yields than the control, 80 lb. N being superior to 40 lb. N. Similar results were obtained in bajra with 40 and 20 lb. N per acre.

iii. *Phosphate manuring of berseem.*—Highest yields of berseem were obtained by NPK and NP treatments. The effect of potash was, however, not significant. Addition of N to P gave higher yields than P alone. All plots treated with P alone or in combination with N and/or K gave significantly higher yields than the control in the succeeding cotton and wheat crops. In another experiment, 64 lb. P_2O_5 per acre as super or F. Y. M. or their combinations applied to berseem for 3 years gave significant after-effects on wheat.

iv. *T. C. M. fertilizer experiments on wheat.*—There were no significant differences in yield from either the type of fertilizer used or in the time of their application in an experiment with ammonium sulphate, ammonium nitrate and urea. Placement of phosphatic fertilizers did not show significant effect. Forty pounds of N or P_2O_5 per acre showed significant differences over 20 lb. N or P_2O_5 per acre and the control. Two and three irrigations were also found to give significantly higher yields than one irrigation.

C. Cultural Experiments

There were no significant differences between shallow and deep ploughing for growing maize, wheat, cotton and potato. In sugarcane and carrots, however, deep ploughing gave better results. Results obtained during the last four years showed that nine ploughings with country plough gave, under irrigated conditions, the best yields of wheat.

In a date of sowing experiment, significantly high yields were obtained when cotton was sown in April and May, jute in March and April, maize on 10th July and phulwa variety of potatoes on 14th October and 5th November.

In a spacing experiment in potato (phulwa variety), significantly higher yields were obtained from $1\frac{1}{2}'$ and $2'$ spacing between rows than from $2\frac{1}{2}'$ spacing.

D. Irrigation Experiments

In berseem, fourteen irrigations, each of 3" depth, gave significantly better result than 10 irrigations. Irrigation intervals of 10 and 12 days gave significantly higher yield of sugarcane than irrigating at 7 days' interval.

E. Varietal Trials

The following varieties of the crops showed superior performance in a series of varietal trials:—chilli (pungent), N. P. Hyb. 5-1-5; bajra, Ph 755 and Bombay 207; cotton, M4, F. 216/14, F. 23, B. C. 68 and 0-394; maize hybrids, Dixie 22 and 33, N. Carolina 27 and U.S.A. 13; and maize, Kanpur 41.

F. Seed Distribution

The total quantity of seeds of improved varieties of wheat, oats, barley, maize, cowpeas, soybean and other crops distributed during the year was 1,060 maunds. In addition, 1,738 seed samples of grasses and legumes and 1,089 crowns of kudzu vine were also distributed.

G. Intensive Cultivation Scheme

Considerable progress was made in the agronomic work under the scheme in 19 villages in the Delhi State. A total of 479 demonstrations showing the value of new varieties, fertilizers and improved cultural practices were made as against 244 in 1952-53 and 311 in 1951-52. The area under the variety N. P. 718 reached 232 acres.

H. Agronomic Experiments on Wheat Rusts

Agronomic practices like date of sowing, effect of N, P and K fertilizer treatments, irrigation and mixed cropping did not show significant effect on the incidence and intensity of rust attacks on wheat in experiments conducted at Pusa. At New Delhi, the intensity of rust infection was greater in plots receiving higher dose of N and NPK. A higher percentage of plant infection was also noticed in plots which were given three irrigations and 40 lb. N per acre.

I. Agrostology

Among grasses, *Brachiaria brizantha*, *B. mutica*, *Setaria sphacelata* and *Urochloa mosambicensis* gave high yields of forage. *B. mutica* yielded 2,133 maunds per acre of green fodder in seven cuttings under sewage irrigation. Among legumes, *Lupinus termis*, *Phaseolus lathyroides*, *Desmodium purpureum*, *D. scorpius* and *D. cephalotus* showed promise.

In a ley farming experiment, the yields of wheat and maize after the ley of *Dichanthium* mixture, *Cenchrus* mixture and Rhodes grass mixture were significantly higher than that of the control plot (maize-wheat rotation).

J. Cattle Breeding and Management

The wet and overall averages of the Sahiwal herd during the year were 23.1 lb. and 13.5 lb. respectively. Among 11 cows which completed their lactations, two gave over 10,000 lb. of milk yield. One heifer gave over 8,000 lb. in her first lactation.

The average weights at birth were 61.2 lb. for a male calf and 56.2 lb. for a female calf. The growth rate was 1.4 lb. per head per day for both male and female calves.

The performance of the early maturity cows and heifers were as follows :—

First calver, 8,856 lb., second calvers, 5,939 and 6,852 lb. in the first and second lactations ; and third calvers, 6,421, 6,927 and 7,715 lb. in the first, second and third lactations respectively.

The work under the Key Village Scheme was started in March, 1954 in the 19 villages under the Intensive Cultivation Scheme.

K. Agricultural Research Sub-Station, Karnal

The total rainfall recorded during the year was 36.18 inches, which is 10.29 inches above the normal. The winter rains accompanied by high wind and hail-storms in February caused heavy lodging in wheat and oats. The wheat crop was also adversely affected by rust and bunt diseases.

I. Manurial Experiments

Manurial experiments were in progress in paddy and wheat. In paddy, green manuring with *dhaincha* with or without phosphate produced significantly higher yield than ammonium sulphate which in turn proved significantly superior at 40 and 20 lb. N per acre to 'no manure'.

Manuring the nursery at 1,000 and 2,000 maunds of F. Y. M. per acre did not produce significant effect. Manuring the fields at 40 lb. N per acre as ammonium sulphate proved significantly superior to 40 lb. N as F. Y. M. Ammonium sulphate, ammonium sulphate nitrate and ammonium chloride at 20 lb. N per acre did not differ among themselves, but were significantly superior to 'no manure'.

In a paddy-wheat rotation, 30 or 60 lb. N per acre as ammonium sulphate and 60 and 120 lb. P_2O_5 per acre produced significantly superior yield to 'no nitrogen' and 'no phosphate' respectively. The interaction between N and P was also significant. While application of nitrogen at 30 and 60 lb. per acre gave significant residual effects, phosphate had no such effect.

In wheat, ammonium sulphate, ammonium sulphate nitrate and ammonium chloride at 20 and 40 lb. N per acre gave similar yields in comparison to one another, but significantly superior yields to 'no manure'. Ammonium sulphate at 40 and 20 lb. N per acre gave a superior yield than 'no nitrogen'. Twenty cartloads of F. Y. M. gave the same yield as 10 cartloads, but the yields from both these treatments were superior to 'no F. Y. M.'.

II. Cultural Experiments

No significant differences were found in the yield of wheat when the seed beds were prepared with tractor plough and with bullock-drawn inversion or non-inversion ploughs. In paddy, broadcasting of seeds, drilling of seeds and transplanting of seedlings gave statistically insignificant differences in yield.

III. Varietal Trials

The following varieties of some of the important crops showed superior performance in yield trials:—wheat, N.P. 718, N. P. 721, N. P. 797, N. P. 798, N.P. 799, and C. 591 (N. P. 718 was the best among these); jowar, C-10-2, J. C. 20 and J. C. 21; linseed, R. R. 45, R. R. 236 and R. R. 272; and cotton, F. 320, F. 216/14, F 216/17, F. 216/3 and F. 216.

IV. Seed Supply

About 489 maunds of seeds of improved varieties of crops were distributed.

AGRICULTURAL ENGINEERING

A. Tests of Tractors

Field and laboratory tests were conducted on a 'Sona' tractor which was assembled and submitted by Messrs. Howrah Trading Co., Ltd., Calcutta. Tests of the tractor were made by using the available draw-bar of an "Allis-Chalmers B" tractor with suitable modifications and a Massey-Harris single furrow plough of the mould-board type. The tractor was tried in ploughing and discing operations. It could plough to a depth of $3\frac{1}{2}$ " but in discing it could not penetrate more than $1\frac{1}{2}$ to 2 inches. A few defects in design and construction of the tractor were noted and suggestions have been made for remedying the defects and incorporating some improvements.

B. Test of a Pull-Meter

A pull-meter (dynamometer) reading upto 10,000 lbs. in steps, supplied by Messrs. Associated Exports and Imports Corporation, Calcutta, was tested in the workshop by recording the draw bar pull of a "Deutz" single cylinder tractor. The pull recorder was rendered out of action by a jerk during the course of the experiment and the pull-meter was returned to the firm at their request.

C. Experiments on Implements for preparing seed beds

A new type of country plough share, called "Bose plough", was received from the Assistant Project Officer, Madurai, for being tested at the Division. The performance of the plough was not satisfactory in dry cultivated lands but the plough was found suitable for puddling work with 1 or 2 inches of standing water in the field.

D. Experiments on Implements for the cultivation and processing of rice

i. *Land Puddler*.—In order to design a cheap puddler for use in rice fields, a mould-board plough to which two sets of attachments of rotating blades had been fixed, was tried in the plots of the Central Rice Research Institute, Cuttack. A puddler manufactured by Messrs. P. S. G. Industrial Institute, which has three sets of rotating blades mounted on suitable axles in a frame, was also tested and was found to give better performance than the former.

ii. *Japanese paddy sheller*.—A Japanese power operated rubber-roll paddy sheller, received from the Central Rice Research Institute, Cuttack, worked satisfactorily with an output of 220 lbs. of paddy per hour causing no breakage at all. The rice shelled by this machine required polishing and no bran was produced.

Another Japanese power-operated paddy sheller known as "Zuiko" sheller was obtained from Messrs J. Khushaldas & Co., Bombay, for trial. This sheller gave an output of 820 lbs. of paddy per hour causing no breakage of rice. No bran was produced and the rice shelled by this machine also required polishing separately.

iii. *Japanese Grain Screen*.—This Screen, which consists of four sieves of different mesh sizes and separates grains from weeds, chaff, stones, etc., was tried with wheat and paddy. The grading of grain was satisfactory and it was found that could screen about 259 lbs. of paddy and 321 lbs. of wheat in an hour.

iv. *Japanese Rice Polishing Machine*.—This machine, operated by a 2 H.P. electric motor at a speed of 1400 R. P. M., caused almost no breakage of rice when the pressure plate was elevated to a raised position. It was capable of polishing about 205 lbs. of shelled rice per hour.

E. Irrigation Devices

i. *Persian wheel*.—A few types of Persian wheels, now in use in the different parts of the country, were tested and the percentage of their overall efficiency was worked out. The efficiency varied between 44 and 52 per cent. and the output of water ranged from 2,000 to 4,000 gallons per hour.

ii. *Charsa*.—With one pair of bullocks, *charsa*—a popular indigenous water lift with leather buckets—gave an output of 1,600 gallons of water per hour lifting from a depth of 53'-6". With two pairs of bullocks, the delivery was 4,800 gallons from a water level at 38' depth.

iii. *Bullock-operated Pumps*.—Two models of bullock-operated water pumps, manufactured by Messrs. Lakshmi Engineering Works, Delhi, and Zamindar Foundry, Batala, respectively, were assembled and tried. Both pumps required some modifications and hence the trials were inconclusive.

iv. *Circular Mhote*.—In a test of an improved circular mhote with differential pulleys attached alternately on vertical and horizontal plane, it was found that the efficiency of the water-lift decreased when the differential pulley was used on the horizontal plane. The maximum percentage of efficiency obtained was 33.94 lifting from a depth of 28 feet.

F. Hand operated Cotton gin

With a view to reducing the cost of construction of cotton gin, a model of the hand operated cotton gin was fabricated in wooden parts, using only a few steel parts. The output of this gin did not exceed that of the indigenous one of the same size. The cost of operation per maund of lint cotton by the indigenous or improved one was more than that of a mechanical gin used in large establishments. Hence the hand operated cotton gins can be recommended only for cottage scale use.

BOTANY

A. Plant Breeding and Genetics

i. *Breeding rust and smut resistant wheat varieties*.—Further progress was made in the breeding of rust and smut resistant wheat varieties at Delhi, Simla, Pusa and Indore under the Co-ordinated Wheat Rust Control Scheme. The reaction of several indigenous and exotic wheat varieties and progenies of over 800 crosses was studied under artificial infection with rusts. E. 2564, an exotic wheat appeared to be resistant to all the three rusts and there were some which showed resistance to one or two of the rusts. N. P. 801 was highly resistant to all the three rusts. N. P. 809, which is resistant to all the three rusts, has done very well in Himachal Pradesh and has thus shown the value of planned breeding work.

Yield trials of the new N. P. wheats were conducted in about 150 centres representing the entire wheat tracts of India. The results suggested that N. P. 710

is suitable for Uttar Pradesh, Madhya Bharat, Saurashtra and West Bengal ; N. P. 718 for Delhi and Rajasthan ; N. P. 755, N. P. 758 and N. P. 761 for north Bihar ; and N. P. 770, N. P. 809 and Ridley for Himachal Pradesh and the hilly tracts of Punjab and Uttar Pradesh. There has been a great demand for seeds of these improved strains, there was a demand for over 6,000 maunds of seeds while only 3,000 maunds could be produced at the Institute.

Some newly bred strains like N. P. 797, N. P. 798 and N. P. 799 have given outstanding yields at Delhi, Karnal, Patna, Pusa and Cuttack. They are highly resistant to loose smut and at the adult plant stage, to all the three rusts. N. P. 799 again yielded more than the improved Bihar variety, B. R. 319 at Pusa.

ii. *Linseed*.—The high yielding, rust-resistant strains—N. P. (R. R.) 5, 9, 10, 37 and 45 were also found to be highly resistant to wilt. Seeds of some of these strains are being multiplied in the different States for distribution ; e.g., N. P. (R. R.) 5 and 45 in Bihar, N. P. (R. R.) 9, 204 and 262 in Madhya Bharat, N. P. (R. R.) 272 and 267 in Madhya Pradesh and N. P. (R. R.) 5 in Rajasthan. The wilt resistant strains, N. P. C. 15 Pusa, N. P. C. 15 W. E., and N. P. C. 38 again showed superior performance at Delhi and Pusa. The Director of Sugarcane Research and Development, Bihar, has arranged to multiply seeds of N. P. C. 15 Pusa for distribution in that area.

iii. *Chilli*.—Among the pungent and non-pungent varieties, N. P. 46 A and N. P. Hyb 5-1-5, and "Bell Pepper" and R. 449 respectively gave the highest fruit yields in trials at Delhi and Pusa.

iv. *Tobacco*.—The new tobacco (*Nicotiana rustica*) selections, S. 19 and S. 20 (now designated N. P. 219 and N. P. 220) have been released for distribution and are in demand in Delhi State.

v. *Tomato*.—The American variety "Sioux" has proved to be a superior cropper and is in demand in Hyderabad and Madhya Pradesh. The crosses Sioux x Meeruti and Red cloud x Meeruti have yielded some promising selections. F_1 plants of Sioux x Meeruti showed marked heterosis with reference to fruit yield, the yield of the hybrids being 23.6 per cent more than that of the superior parent (Sioux).

vi. *Bhindi*.—Work is in progress on breeding for high yield and resistance to yellow vein mosaic. Some varietal hybrids showed heterosis in respect of fruit yield.

vii. *Bajra*.—Baroda 207 gave the best yield in irrigated trials. U. P. type 55 and Gwalior 2 were the most suitable under *barani* conditions.

viii. *Maize*.—Inbreeding of Indian varieties was continued. A total of 540 inbred lines were studied and selections were made for further inbreeding. F_1 hybrids of five crosses among open-pollinated varieties gave 1 to 40 per cent more yield than the respective superior parent. Among the American maize hybrids tried at 24 centres, Dixie 22, Dixie 33, N.C. 27 and Georgia 281 again out-yielded local varieties at many centres.

ix. *Forage crops*.—A collection of indigenous and exotic varieties of fodder grasses and legumes was studied with a view to evaluate the possibilities of breeding superior strains for northern India. A strain of *Cenchrus ciliaris* obtained from Australia was highly heat and drought resistant.

B. Cytology and Cytogenetics

i. *Autopolyploidy*.—Continued mass pedigree selection markedly increased the frequency of high fertile plants in colchicine-induced autotetraploids of *Brassica campestris* var. *toria*. Lack of fertilisation of a good percentage of ovules seemed to be responsible for low seed setting in autotetraploid *toria* and linseed.

ii. *Triticum*.—Cytogenetical studies in interspecific hybrids and induced amphiploids were continued. Three nullisomic lines were isolated from the F_4 progeny of the pentaploid hybrid *T. vulgare* X *T. pyramidale*.

iii. *Techniques*.—A technique has been developed for obtaining excellent microscopic preparations of mitosis in pollen grains of species of *Triticum* and allied genera. This, and the root tip-squash technique developed last year are proving very valuable in the study of the karyotypes of these species.

iv. *Bhindi*.—A fertile amphiploid from the sterile hybrid between cultivated *bhindi* (*Abelmoschus esculentus*, $n=65$) and the wild, yellow-vein-mosaic resistant species, *A. tuberculatus* ($n=29$) has been obtained and is being used in breeding work. The results from a cytological study of F_1 *A. esculentus* X *A. tuberculatus* suggest that the cultivated species is an amphiploid comprising of two genomes, one with 36 and the other with 29 chromosomes, the latter genome being homologous with that of *A. tuberculatus*.

C. Crop physiology

i. *Study of drought resistance in wheat*.—Varieties with higher ear number per plant and grain number of ear appeared to do relatively better than the others under drought pressure. The newly-evolved, high yielding, rust-resistant variety, N. P. 798, which possesses these characters, seems to be relatively more drought resistant. Employing these criteria, selections are now being made in crosses involving N. P. 52, Gabo, Pb. C. 228, N. P. 789 and N. P. 798.

In an experiment with three wheat varieties, three sowing dates and two levels of nitrogen supply, differences between the varieties in number of spikelets per ear and 1000-grain weight were found to persist consistently in the different seasons.

In a field experiment with three wheat varieties, Pb. C. 591, N. P. 165 and Baluchistan-16, sown on three different dates, Pb. C. 591 had a higher rate of increase of dry weight of grain per day and as a consequence, it gave higher yields than the others under late sowing.

ii. *Plant hormones*.—When sprayed with different concentrations of two plant hormones, indole-acetic-acid and α -naphthalene acetic acid, the wheat variety N. P. 710 gave 17 maunds per acre more yield than the unsprayed controls. Pb. C. 228, on the other hand, gave no such response. Spraying flower clusters of tomato with 2, 4-D solutions led to a 13 per cent increase in fruit yield (resulting from an increase in number of fruits per plant). Fruit formation and maturity were also hastened by about a week. Spraying whole plants was in general not found to be beneficial.

iii. *Lodging in wheat*. It was observed in a trial involving three wheat varieties, three levels of nitrogen supply and four dates of application of nitrogen that the extent of lodging diminished, in general, with delayed application of nitrogen. Applications even as late as 90 days after sowing reduced lodging and did not adversely affect grain yield.

D. Systematic Botany and Plant Introduction

Plant Introduction.—The foreign introductions and indigenous collections during the year numbered 904 and 880 items respectively. The total collection now comprises of 9565 items.

Among the older introductions, the Chinese sweet potato variety, F. A. 17, the American tomato variety, Sioux, the vegetable variety of cowpea, Philippines Early, and the American garden-pea variety, Early Badger, are becoming popular. The promising newer introductions include some highly rust resistant wheat varieties; an orange-fleshed sweet potato selection rich in carotene content; the onion variety "Byar Grano" and hybrid H. 4503-6 from America, two water melon varieties-Asahi Yamoto II from Japan and New Hampshire Midget from America; and *Sorghum alnum*, a drought resistant fodder grass.

E. Horticulture

The object of this section which commenced working in April, 1954, is to develop research work on fruit and vegetable plants. A garden of eleven acres planted with varieties of mango and loquat by the Central College of Agriculture was taken over. The garden area is being extended and will ultimately cover 30 acres.

SOIL SCIENCE AND AGRICULTURAL CHEMISTRY.

A. Agricultural Chemistry

i. *Nitrogenous manures.*—Ammonium chloride and ammonium sulphate-nitrate proved as efficient as ammonium sulphate in studies on the use of fertilizer for increased crop growth.

ii. *Dicalcium phosphate.*—This fertilizer, which is comparable in efficiency to superphosphate, does not involve the use of sulphuric acid in its manufacture. Its successful production on a pilot scale at the National Chemical Laboratory offers scope for its increased use in the country.

B. Soil Chemistry

i. *Phosphatic fertilization of berseem.*—Manuring of berseem with superphosphate alone in the rotation berseem-wheat gives high yields of both the crops. On the other hand, each of the crop in the rotation maize-wheat need to be fertilized with both nitrogen and phosphorus for obtaining optimum yields.

ii. *Rapid methods of soil analysis.*—Rapid chemical tests have been evolved to assess the fertility status of soils so that farmers can be advised on the judicious use of fertilizers.

C. Micronutrients

Application of molybdenum at the rate of 2 lb. of molybdenum oxide per acre along with nitrogen and phosphorus gave increased yields of berseem in black cotton soils. No such increase was found in Delhi soils.

D. Soil Survey¹

A soil and land utilization survey of the little Rann of Kutch showed that about 3 lac acres in this salty tract, 1400 square miles in extent, may be suitable for reclamation and subsequent agricultural use.

E. Physical Chemistry

i. *Soil texture*.—Application of green manure improved the physical condition of the soil in respect of water stable aggregates more than the application of farm yard manure or lime.

ii. *Alkali soils*.—The mineral constitution of clay, concentration of salts and the nature of the dominant salt were found to be the effective factors in sodiumization of soils.

Some saline patches on the farm at Pusa have been formed by the movement of water from underground water mounds. The water dissolves and accumulates salts during its passage through sub-soil and, at a certain stage of salinity, rises up due to improved permeability.

F. Organic Chemistry

i. *Preparation of Nicotine sulphate*.—Nicotine sulphate containing 40 per cent nicotine could be prepared by concentrating a kerosene oil extract to tobacco waste through a specially designed extractor.

ii. *Longifolyl compounds*.—Longifolyl thiocyanate synthesized at this Division gave 78 per cent control against mustard aphids without being phytotoxic. Longifolyl alcohol formed during the preparation of longifolyl thiocyanate acetate has shown promise as a fixative in perfumery.

iii. *Estimation of tocopherol content of oils*.—A new method for the estimation of tocopherol content of oils in small samples has been developed.

iv. *Detection of adulteration of fats*.—Ethyl tyrosinate, which when added to hydrogenated fats serves as an indicator to detect adulteration, was found to be stable upto 230°C and to be unaffected during storage. Its use in trade would afford a sensitive test to detect adulteration.

G. Physics

Emission and absorption spectrographic techniques for the estimation of major and micro-elements as well as plant products were developed for use in routine analysis and research work.

H. Biochemistry

Quality of wheat, pulses and tomatoes.—Examination of the nutritive value of Indian foods showed that thiamine content of some of the varieties of wheat and pulses varied between 4 and 6 mg. per gram. Nicotinic acid varied between 41 and 64 mg. per gram in the same wheat variety when grown in different localities. Manurial treatment greatly influenced the mineral composition. Vitamin C content of different varieties of tomatoes was found to vary between 18 and 70 mg. per 100 gm.

I. T. C. A. trials

With the aid received under T. C. A., field trials are in progress at 40 centres in both research plots and cultivators' fields to study the performance of different nitrogenous and phosphatic fertilizers. This work is linked up with a collaborative soil survey of these zones for comparing crop response on different soil types.

ENTOMOLOGY

A. Parasitology

i. *Lestodryinus pyrrillae* Kieff.—Studies on the bionomics and some important aspects of the morphology and musculature of *Lestodryinus pyrrillae* Kieff. (Hymenoptera : Drynidae), a nymphal parasite of the sugarcane pest *Pyrrilla* sp. were completed.

ii. *Sex-ratio in some parasites*.—Studies on the effect of alternate hosts on the sex-ratio of *Stenobracon deesae* Cam. (Hymenoptera : Braconidae) showed that there is an increase in the percentage of females generation after generation when the parasites are reared on their natural host *Chilo zonellus*. On the other hand, the production of females stops after the second generation when the parasites are reared on the laboratory host *Corecya cephalonica*. Thus, *Corecya cephalonica* does not appear to be a suitable alternate host for mass breeding of the parasite.

Studies on the effect of some factors on the sex-ratio of *Bracon gelechiae* under mass breeding conditions showed that the parasite indicated preference to larger hosts for egg-laying and that a higher percentage of emergence of female occurred in the natural host *Chilo zonellus*. The optimum temperature and humidity percentage for a high sex-ratio in the progeny were found to be 25°C and 60 per cent respectively. Restraining from egg-laying for 24 hours increased the percentage of females but decreased the egg-laying capacity. Bright light and protein food increased the percentage of females.

Microbracon pupae when subjected to refrigeration at a temperature of $10 \pm 3^\circ\text{C}$ for a period of 5 to 30 days showed that the viability, fecundity, longevity and sex-ratio of the progeny were highly reduced with increase in the duration of refrigeration.

iii. *Miscellaneous studies*.—A new technique for breeding *Apanteles angaleti* Mues. on *Corecya cephalonica* was evolved. The life-history of this parasite was worked out.

The chaetotaxy of the larva of various species of *Bracon* and *Stenobracon* was worked out. Catalogues of the Tribes *Rhyssini*, *Acaenitini* and *Ephialtini* of sub-family *Pimplinae* and of the tribe *Lissonotini* of the sub-family *Banchinae*, both belonging to the family *Ichneumonidae* were completed.

Breeding of the parasites *Trichogramma evanescens minutum* Riley (Hymenoptera : Trichogrammatidae), *Bracon gelechiae* Ashm., *Apanteles angaleti* Mues. (Hymenoptera : Braconidae) was continued and cultures were maintained.

B. Systematic Entomology

i. *Thysanoptera*.—Studies on the male genitalia of 8 genera comprising of 15 species showed that the genital structures are of diagnostic value.

ii. *Coleoptera*.—Systematic studies of the sub-family *Otiorrhynchinae* were taken up and the preparation of a catalogue of this sub-family was started. Various specimens in the National Pusa collection were studied.

iii. *Orthoptera*. Thirty-one species belonging to 11 representative genera were taken up for studies on external morphology. Genital structures of male and female forms were studied in 21 species. A new species of *Oryza* was described. For the first time, a relationship was established between the Elytron/Hind Femur ratio in the gregaria and solitaria forms and the relative length of the lophi (paired posterior process) of the epiphallus in *Schistocerca gregaria* Frosk. Male genitalia of *Schistocerca gregaria* and that of *S. americana* (Drury) were compared and differences recorded.

iv. *Lepidoptera*.—Eighty-five species belonging to 25 genera of Noctuidae were studied with reference to morphological characters and structures of the male and female genitalia. The genital studies suggest that certain species of *Plusia*, *Euplexia*, *Leucania*, *Agrotis*, *Amyna* and *Eublemma* should be removed from their present systematic position and assigned to other genera.

v. *Hymenoptera*.—Comparative studies on the male genitalia in 4 genera and 20 species of Eumeninae were completed. The results suggest that the genera *Rygchium* and *Odynerus* are synonymous since even the pygidium and hypopygidium do not show significant differences. A catalogue of Eumeninae was completed and a catalogue of *Vespinæ* was taken up. A new variety of *Polistes hebraeus* was described.

C. Ecology and Toxicology

i. *Ecological studies on Phadka (Hicroglyphus nigrorapetus Bol.)*.—It was found that egg pods softened by keeping them in moist soil for about 8-10 days had no effect on the viability of the eggs. About 70 per cent of eggs were viable after such a treatment. Attempts to break the diapause of eggs laid in 1952 were successful. The effects of temperatures 20°, 25°, 30° and 35°C and 50 per cent and 75 per cent relative humidity on nymphal periods were studied.

ii. *Construction of Biometer for Trichogramma evanescens minutum Riley*.—Based on the data collected so far an equation connecting temperature and developmental index was worked out.

iii. *Bioassay of insecticides*.—Observations on the relative toxicity of hydrogen cyanide, methyl bromide, carbon disulphide, chlorosol, ethylene dichloride and carbon tetrachloride to the grubs of the storage pest *Trogoderma granaria* and adults of *Tribolium castaneum* were continued. The relative toxicity based on LC 50 were in the order hydrogen cyanide > methyl bromide > carbon disulphide > chlorosol = ethylene dichloride > carbon tetrachloride.

iv. *Relative toxicity of insecticidal dusts and films to storage pests*.—Comparative studies on toxicity of 6 insecticidal dusts, viz., DDT, BHC, Aldrin, Dieldrin, Toxaphene and Chlordane to *Tribolium castaneum*, *Calandra oryzae* and *Bruchus* sp. and of 6 insecticidal films to *T. castaneum* and *Bruchus* sp. were carried out. Dieldrin was most toxic to *T. castaneum* and *Bruchus* sp. and gamma BHC to *C. oryzae*. Aldrin as film was most toxic to both *T. castaneum* and *Bruchus* sp. Multiplication of *Trogoderma granaria* and *Corepra cephalonica* can be checked by mixing DDT

or Toxaphene dusts at the rate of 20 to 80 p.p.m. or gamma BHC, aldrin, dieldrin or Chlordane at the rate of 10 to 40 p.p.m. approximately.

v. *Preliminary tests of Chemicals synthesised in the Chemistry Division.*—

Six chlorinated terpene products synthesised in the Chemistry Division were tested on adults of *Tribolium castaneum*. The effectiveness was of the following order technical toxaphene > chlorinated delta 3 carene > chlorinated pinenene > chlorinated terpineol > chlorinated longifolene.

vi. *Toxicity of insecticidal sprays to Leptocoris varicornis.*—Six modern insecticides and pyrethrum were tested at five different concentrations in the laboratory for their toxicity to Gundhy bug on paddy. All the insecticides caused nearly 100 per cent mortality within 24 hours.

vii. *Relation between insecticidal effect and instar characters of the Desert locust.*—Studies on successive instars of the desert locust *Schistocerca gregaria* showed that (a) surface area per unit weight, (b) percentage of wax in the exuviae, and (c) the probable thickness of the exuviae are most likely to affect the entry of the insecticides in different instars.

viii. *Studies on control schedules.*—In order to evolve a schedule of control operations against aphid infestation in mustard crop, six insecticidal spray formulations were tried in a replicated field experiment. Though the aphid population after each spraying differed in the different treatments, the mean yields did not show any significant difference.

ix. *Effect of temperature on susceptibility.*—DDT emulsion, DDT suspension, BHC emulsion, toxaphene emulsion, chlordane emulsion and parathion emulsion were tested under different post-treatment temperatures on *Tribolium castaneum* adults pre-treated for 24 hours at about 14°C and 50-55 per cent humidity. The results in 3 out of the 6 formulations showed that an increase in the post-treatment temperature within limits decrease the toxic effect. There is also a similarity between the curves obtained by plotting the values of LC 50 for DDT and gamma BHC formulations against different post-treatment temperatures and the curves published by various workers connecting temperature with various physiological activities. Thus, the graphical relation between post-treatment temperature and insects resistance to insecticides has been demonstrated for the first time.

x. *Treatment temperature coefficient of insect resistance to insecticide film.*—Higher temperature gave more mortality in tests with DDT films of five strengths with *Tribolium castaneum* adults.

MYCOLOGY AND PLANT PATHOLOGY

A. Plant Pathology

i. *Wheat Rust.*—Two hundred and eighty-two samples of black, brown and yellow rusts were analysed and races 21, 34, 40, 42, 194 and C of black rust, 10, 11, 20, 26, 63, 106, 107 and 108 of brown rust and 19, 31, A and D of yellow rust were identified among them. It is for the first time that Race C of black rust, which is closely allied to race 72, has been isolated. The predominant and widely distributed races were 21, 40 and 42 of black rust, 20 and 63 of brown rust and 19 and A of yellow rust. Race 34 of black rust appears to be on the increase whereas race 42 is on the decline. A colour mutation in race 15-C of black rust was observed,

Rust collections from 38 grasses from different parts of the country did not reveal any new collateral host. Evidence was obtained of over-summering of black and brown rusts in the Western Ghats at Panchgani and Mahabaleshwar, thus indicating the possibility of local foci of infection for the wheat crop of Bombay State.

In the seedling resistance tests, varieties E. 2025, N. P. 789 and N. P. 790 were found to be susceptible only to race 122, and E. 931 to race 15-C. Varieties E. 928, F. 931, E. 952, E. 957, E. 1951, E. 2025, E. 2158 and N. P. 815 proved resistant to all the races of brown rust. The results of yellow rust inoculations were not conclusive. About 83,000 plants were tested for adult resistance against all the three rusts and about 1,300 resistant cultures and plants have been selected for further study.

The efficacy of finely powdered sulphur, 0.3 per cent ultra sulphur, 0.1 per cent hydrophobic colloidal sulphur and 0.1 per cent dithane in the control of wheat rusts was tested. Infection from trace to 20 per cent was noted in weekly dusted or sprayed seedlings while the controls showed 50-60 per cent infection. Fort-nightly application gave about 50 per cent control. All the four fungicides were equally efficacious, but 0.2 per cent dithane showed some phytotoxicity on the upper leaves.

ii. *Loose Smut*.—Among 145 wheat varieties tested for their resistance to the disease at Delhi and Simla, 92 remained free from infection.

iii. *Bunt*.—The European bunt fungus, *Tilletia foetida*, was brought into culture. When seeds of wheat varieties N. P. 770, N. P. 801 and N. P. 809 were artificially infected with chlamydospores at the time of sowing, the percentage of infection obtained was 41, 80 and 67 respectively.

Karnal bunt appeared in an epidemic form this year in Delhi State and in some neighbouring districts of the Punjab and Uttar Pradesh. The wheat variety Punjab C. 591 was affected most and relatively greater infection was observed in the irrigated tract than in the *barani* crop.

iv. *Barley Rust*.—Seventeen rust collections of barley yielded races 21 and 34 of black rust, and races A and 19 of yellow rust. Among 15 varieties tested none had resistance against individual races of black and yellow rusts in the seedling stage. In the adult resistance test, however, varieties B. 70 and B. 75 proved to be resistant to a mixture of all the 10 races of yellow rust.

v. *Sugarcane Red Rot*.—No evidence of physiologic specialization in *Colletotrichum falcatum* was obtained in a test of 32 isolates of the fungus collected from various cane-growing tracts of the country on 10 standard cane varieties. No variety was found to be resistant among the 201 cane varieties tested by the standard Plug method and 111 through the nodal regions. Forty-one varieties, however, behaved as moderately resistant in tests by the Plug method.

vi. *Sugarcane Smut*.—In the Smut varietal resistance tests carried out with 98 cane varieties at Delhi and 99 varieties at Karnal, 24 proved resistant and 13 as moderately resistant.

vii. *Linseed rust*.—Nineteen samples of linseed rust were studied and evidence was obtained of the occurrence of a new race, besides the four races of *Melampsora*

lini so far reported in India, in the collections from Punjab. The new race can be distinguished from the existing four races by its reaction on the auxiliary differential *Argentine Selection* C. I. 705-1.

In a varietal resistance test with 30 varieties, 21 were resistant or immune to all the four Indian races in the seedling stage. Ninety-four varieties were tested against a mixture of the 4 races in the seedling and adult stages and of them, 53 were resistant or immune, 19 were semi-resistant and the rest were susceptible.

The following *Linum* species were found to be immune to all the four Indian races: *L. trigynum*, *L. marginale*, *L. africanum*, *L. angustifolium* and *L. coeruleum*.

viii. *Pigeon-Pea Wilt*.—Varieties N. P. 41, C. 15 W. E., and N. P. 69 $\times$ U. P. 132-3-2-2 were completely resistant to wilt both in the field and in pots.

ix. *Bajra green-ear disease*.—In pot and field experiments to study the viability of oospore material of *Sclerospora graminicola*, which had been exposed for weathering since 1952, the percentage of infection was 4.4 and 3.5 respectively. Oospore infested soil, which gave successful infection last year and had been exposed to weathering conditions since then without the addition of any fresh inoculum, gave 1.5 per cent infection again this year, thus indicating the persistence of infection in soil and germination of oospores at varying intervals.

B. Antibiosis

The antibiotic from *Bacillus subtilis* was fungicidal to *Alternaria solani* when the spores were presoaked for 24-48 hours in the culture filtrate. The biological spectrum of the antibiotic was investigated and its action on most of the test organisms was found to be fungistatic. The unautoclaved culture filtrate showed inhibitory activity but its bulb-forming activity was almost negligible. There was, however, a marked increase in the bulb-forming activity after autoclaving. The bioassay method of the bulb-forming principle was standardized using *A. solani* as test organism and n-isopropyl alcohol was found to be a good solvent for the antibiotic. The uptake of the antibiotic by tomato plants was confirmed.

C. Physiology of fungal Parasitism

Sporulation of *Lophotrichus ampulus* was demonstrated to be dependent on the availability of biotin. Presence of sucrose as carbohydrate source was necessary for sporulation and substitution of sucrose with glucose in an otherwise complete medium inhibited sporulation. In tissue culture studies, root cultures of safflower were established on Gautheret's medium, containing sucrose instead of glucose, and grown for six generations.

D. Fungicides

Fungicidal seed dressing gave only slight increase in yield in maize but in *bajra*, besides a slight increase in yield, there was an increase in germination and tillering. A small increase in average height of the crop was observed in wheat but there was no appreciable increase in yield except in the case of Lunasan. A slightly increased yield was obtained in barley with all the five fungicides tested.

The role of soil and seed fungus flora with reference to pre-emergence injury was studied in wheat and maize. It has been established that soil microflora do

more damage than the seed microflora and that if seed microflora are eliminated without giving any subsequent protective covering to the seed the damage caused by the soil microflora is greater. Seed dressing with Spergon in wheat and Agrosan GN in maize proved effective. Preliminary tests using *Trichoderma* spores for seed dressing have given encouraging results.

E. Assessment of damage

In Sugarcane, the crop grown from setts obtained from smutted canes showed a reduction in yield of 48.8 and 54.5 per cent in CO. 312 and CO. 313 respectively. The corresponding figures of reduction when the setts were inoculated at the time of planting were 7.8 and 23.1. In wheat about 29 per cent loss in yield on 1,000 grain-weight basis was observed with 60-80 per cent rust infection.

F. Bacterial diseases

Studies on bacterial "Tundu" disease of wheat (*Corynebacterium tritici*), leaf spot of pomegranate and brown rot of potatoes were continued. The pomegranate leaf spot bacterium appears to be a new species of *Xanthomonas* as it is specific in its pathogenicity to pomegranate.

G. Virus diseases

Five *Lycopersicon* species were tested for their resistance to the leaf curl disease by grafting and feeding of viruliferous white-flies but none of them was immune. The percentage of infection through insect transmission was, however, only 4.2 in *L. peruvianum*. Spraying the crop with "Ekatox", a proprietary parathion insecticide, was found to give effective control of the disease at Poona.

Yellow-vein mosaic of *bhindi* could not be transmitted by grafting to *Abelmoschus manihot* var. *pungens*, *Abutilon indicum* and *Hibiscus vitifolia*, while transmission occurred in *Althea rosea*, *Hibiscus ficulneus* and *H. tuberculatus*.

It was confirmed that chilli mosaic virus remains active when exposed to ultra-violet irradiation for 4 hours (347.72 m.u.d.) but is rendered innocuous after an exposure of 6 hours (514.08 m.u.d.).

Exposure of *Brassica juncea* to ultra-violet light after inoculation with radish mosaic virus appreciably inhibited the multiplication of virus, though exposure of the host plant before inoculation had no such effect. Metabolic products of *Trichothecium roseum*, *Aspergillus niger*, *Fusarium avenaceum*, *Rhizoctonia solani*, *Helminthosporium halodes*, *Colletotrichum lindemuthianum* and *Bacillus subtilis* as well as extracts of chilli leaves inhibited virus multiplication.

It was established that the phyllody disease of *Brassica campestris* var. *toria*, *B. campestris* var. *sarson* (Desi and Yellow) and *B. rapa* was caused by a virus.

The maize mosaic virus was found to be sap transmissible to *Dactyloctenium aegyptium*, *Euchlaena mexicana*, *Sorghum sudanense*, *Sorghum vulgare* and *Coix lachryma-jobi*.

Brinjal mosaic virus was purified and the purified preparation showed anisotropy of the particles suggesting that the particles may be rod shaped.

In studies on virus-vector relationship, it was found that white-fly (*Bemisia tabaci*) is capable of carrying simultaneously two different viruses (yellow-vein mosaic viruses of pumpkin and *bhindi*). The incubation period of the yellow-vein mosaic virus of pumpkin in the white-fly was found to be about 9 hours, both when tested singly or in groups of 20. There was no difference in the incubation period between male and female insects. It was also found that the white-fly retains the virus for the rest of its life after acquiring it.

A virus causing severe systemic reaction on *Nicotiana glutinosa* was isolated from a diseased tobacco plant which had also tobacco mosaic virus in it.

H. Systematic Mycology

Studies in the genera *Cercospora*, *Colletotrichum*, *Phoma* and *Tretopileus* were completed. Studies on Miscellaneous Indian Fungi were continued and 7 new species and 14 new host records were established. A detailed study was made of a leaf spot disease of mango caused by *Macrophoma mangiferae*, a new species of *Macrophoma*. Comparative morphological, physiological and pathological studies were carried out of *Sclerotium rolfsii* Sacc. and *Ozonium texanum* Neal and Wester var. *parasiticum* Thirumalachar to understand their taxonomic relationship.

3. GENERAL FEATURES OF THE REPORT

(i) Land and buildings

Several new buildings were constructed during the year. The construction of laboratory and office buildings of the Wheat Breeding Sub-Station, Simla, a Lecture Theatre in the Botany Division and a portion of the Agricultural Engineering Workshop was completed. The glass houses at "Flowerdale" and Tutikandi in Simla and an Insectory for the Mycology Division at New Delhi were also completed during the year. The construction of a laboratory under T. C. A. was started.

Two 'C' type staff quarters were constructed during the year and work on the building of eight more of such quarters was commenced. A second Hostel for the Post-graduate students is under construction.

(ii) Post-graduate training

Fifty-eight students were selected during the year for the regular post-graduate training in different subjects out of a total number of 180 applicants.

Two students were admitted to the one-year Plant Protection Course while fifteen students were given a short course training in different subjects.

Ten honorary Research Workers were admitted to the different Divisions and four M.Sc. students of the Punjab University were given facilities and guidance in their work.

Forty-two students successfully completed their studies in the 2-year post-graduate course and were awarded the Associateship of the Institute. A list of the theses presented by these students is given in Appendix II.

(iii) Library

The total number of publications and new periodicals received during the year by purchase and exchange were 4,097 and 78 respectively. Out of a total of 6,091 books issued during the year, 1,216 were sent to scientific workers in the different States and Universities. The Reading Room was used by 10,955 visitors and 133,286 books were consulted.

References to literature on various subjects were supplied to the Ministry of Agriculture, Indian Council of Agricultural Research, State Departments of Agriculture, Universities and to individual scientists. Some of the topics on which lists of references were supplied were :—

Vegetation of the Himalayas, organic manures, betel leaf, cultivation of potato in India, effect of polluted atmosphere on vegetation, acidity and alkalinity of Indian soils and green manuring, animal ecology, algae as food, effect and use of “ Krillium ” and soil and water conservation.

(iv) Advisory work

The Institute, as in previous years, attended to a large number of requests for expert advice and help on agricultural matters from both official and non-official sources. The types of problems handled are mentioned below :—

Agronomy.—General cultivation practices, Japanese method of rice cultivation and distribution of seeds of improved varieties.

Botany.—Identification of plants and fruits, notes on growing specific crops, control of weeds by the use of weedicides and germination tests of seeds.

Chemistry.—Analysis of soil, manure and water samples, cobalt and copper content of linseed, groundnut and mustard cakes, methods of improving alkali soils, soils of Andaman islands, manuring of mangoes, soyabean as food, fertiliser use of urea and rapid soil tests.

Entomology.—Identification of insect pests, predators and parasites, examination of samples for insect infestation, supply of coloured plates of crop pests and issue of health certificates.

Mycology and Plant Pathology.—Identification of pathogenic and taxonomic specimens and fungal and bacterial cultures, disinfection of samples, issue of health certificates, and calculation of resistance and susceptibility ratings of sugarcane varieties to red rot.

Agricultural Engineering.—Selection and source of availability of suitable agricultural implements, supply of blue prints of drawings of implements and machinery and scrutiny of schemes on agricultural machinery.

(v) Research Schemes

Work on the following schemes financed by the Indian Council of Agricultural Research (I. C. A. R.), the Indian Central Sugarcane Committee (I. C. S. C.), the Indian Central Oilseeds Committee (I. C. O. C.) and the Government of India,

Ministry of Food and Agriculture (M/F & A) was in progress in the different Divisions of the Institute during the year under report :—

Serial No.	Title of the Scheme	Sponsored by	Division in which the work was in progress
1.	Scheme for the collection of exotic and indigenous pasture grasses and legumes, their testing and distribution, and their breeding for better agronomic characters.	Indian Council of Agricultural Research.	Agronomy and Botany.
2.	Scheme for the improvement of maize crop in India.	Do.	Botany.
3.	Scheme for the establishment of nucleus organisation for the introduction of new economic plants.	Do.	Do.
4.	Co-ordinated scheme for the investigation of micro-nutrients.	Do.	Do.
5.	Scheme for the preparation of a monograph on agriculture in ancient India.	Do.	Chemistry.
6.	Scheme for setting up an experimental gas plant (up to 9-1-1954).	Do.	Do.
7.	Scheme for research on the examination of rapid methods of soil test for soil survey work.	Do.	Do.
8.	Scheme for the studies of chemical composition and nutritive value of wheat.	Do.	Do.
9.	Scheme for the physical properties of fertilizers under storage conditions (up to 23-1-1954).	Do.	Do.
10.	Scheme for tests with D. D. T., 666 and allied insecticides.	Do.	Entomology.
11.	Termite Research Scheme	Do.	Do.
12.	School of Research in Entomology (up to 28-2-1954).	Do.	Do.
13.	School of Research in Mycology—Physiology of Parasitism (up to 15-12-1953).	Do.	Mycology.
14.	Co-ordinated plant virus research scheme . . .	Do.	Do.
15.	Scheme for the production, trial and popularisation of improved agricultural implements (From 3-10-1953).	Do.	Agricultural Engineering.
16.	Co-ordinated Wheat Rust Control Scheme	Ministry of Food and Agriculture (A).	Botany and Mycology.
17.	Key Village Scheme	Do.	Agronomy.
18.	Scheme for research on the diseases of sugarcane	Indian Central Sugarcane Committee.	Mycology.

Serial No.	Title of the Scheme	Sponsored by	Division in which the work was in progress
19.	Linseed Rust Scheme	Indian Central Oil-seeds Committee.	Mycology.
20.	Scheme for research on phyllody diseases of sesamum.	Do. .	Do.
21.	Scheme for agronomical studies on oilseeds .	Do. .	Agronomy.
22.	Scheme for cytological studies on some oilseed crops in India.	Do. .	Botany.
23.	Scheme for the development of a method to determine the unsaturation of a small quantity of oil.	Do. .	Chemistry.
24.	Scheme for agronomic trials of fertilizers . .	T. C. A. .	Agronomy and Chemistry.
25.	Scheme for the determination of soil fertility and fertilizer use.	Do. .	Chemistry.

(vi) Collections and Herbaria

The foreign plant introduction and indigenous collection during the year numbered 904 and 880 items respectively. The total collection now comprises of 9,565 items. Three hundred and eight specimens were added to the Herbarium maintained at the Botany Division. There are 5,390 specimens in the Herbarium now.

Twenty-five cultures of fungi and bacteria were added to the Type culture collection at the Mycology Division bringing the total number of cultures in stock to 945. More than 5,000 subcultures of fungi and bacteria were made during the year. Three hundred and fourteen mycological specimens were added to the Herbarium, bringing the total number of accessions to 20,640. The new accessions included many Type species of fungi, 74 specimens of Skurdorf Fungi and one exsiccati set (Myriangiales Selecti Exsiccati, Fascicle X). One hundred and thirty-four specimens were supplied to various scientific institutes and research workers in the country and abroad. The first exsiccati set from this Herbarium of Indian Uredinales (Fascicle No. 1) was issued to 12 important herbaria in the world.

During the year, holotypes of 5 new species of *Evania*, 4 species of *Bostrychidae* and one species comprising 21 specimens of orthoptera were added to the National Pusa Collection maintained at the Division of Entomology. One species of *Phoracantha septempunctata* received from Israel, *Locusta migratoria migratorioides* R. & F., from London, 5 species of *Formicidae* from California and two American forms, *Schistocerca americana* (Drury), *Melanoplus differentialis* (Thom) were added to the exotic specimens of the National Pusa Collection.

(vii) Intensive Cultivation Scheme

Considerable progress was made in the agronomic work under the Scheme which was started in nineteen villages in August, 1950. A total of 479 demonstrations were given concerning the use of new varieties, manures and fertilizers and improved cultural practices. Two N. P. wheat varieties, 718 and 775, have become very popular among cultivators and 232 acres were saturated with N. P. 718 alone. Oats N. P. 1, barley N. P. 13 and gram N. P. 53 have also become popular. The use of green manures gave an average increase in yield of about 5 maunds per acre in wheat. The highest yield of paddy obtained under the Japanese method of cultivation was 65-43 maunds per acre.

As usual control measures were carried out in these villages against major pests and rodents. Surveys and estimates of the damage caused by pests and rodents were made in these and the neighbouring villages.

(viii) Meetings and Conferences

As usual, the Director, the Heads of the Divisions and other officers of the Institute attended the meetings and conferences held under the auspices of the various Ministries of the Government of India, the Indian Council of Agricultural Research, the various Commodity Committees, etc.

A special mention may, however, be made of the Director's attending the 8th International Botanical Conference held in Paris in June-July, 1954 as a member of the Indian Delegation. The Head of the Division of Mycology attended the 6th International Congress of Microbiology held in Rome from 6th to 10th September, 1953. He was also deputed to attend the 5th Commonwealth Mycological Conference in London and the International Commission on Plant Disease Losses and the Phytopathological Section of the 8th International Botanical Congress held in Paris in June-August, 1954.

(ix) Supply of pedigree seeds and stocks

As in previous years, the demand for N. P. seeds, especially of wheat, from the different States was quite heavy. Since the area available for seed multiplication purposes was limited, the supply of seeds fell far short of the demand. The following quantities of pedigree N. P. seeds of different crops were supplied by the Institute :—

Crop													Quantity of seed distributed (in maunds)
Wheat	.	.	.	.	.	.	.	.	.	.	.	.	908.33
Oats	.	.	.	.	.	.	.	.	.	.	.	.	65.95
Barley	.	.	.	.	.	.	.	.	.	.	.	.	24.31
Maize	.	.	.	.	.	.	.	.	.	.	.	.	41.11
Cowpeas	.	.	.	.	.	.	.	.	.	.	.	.	7.78
Soybean	.	.	.	.	.	.	.	.	.	.	.	.	1.84
Other crops	.	.	.	.	.	.	.	.	.	.	.	.	10.56
Grasses and legumes	.	.	.	.	.	.	.	.	.	.	.	.	1,738 seed samples.
Kudzu vine	.	.	.	.	.	.	.	.	.	.	.	.	1,089 crowns and 82 potted plants,

During the year under review, three cows, six young male stock and one bull were sold and the sale proceeds amounted to Rs. 5,661-0-0.

(x) Patents of Agricultural Machinery

Applications were made for patents of a Jute Seed drill and a Groundnut Planter designed at the Division of Agricultural Engineering. Specifications were drawn up in consultation with the Secretary, Patents Advisory committee of the Ministry of Commerce and Industry and submitted to the Patent office at Calcutta. The groundnut planter has been designed to drop groundnut seeds one by one without damaging the seeds. The Jute seed drill can be used for sowing two or three seeds at one place in rows at any required spacing.

A Rotary Screen has been built at the Agricultural Engineering Division which helps to separate undesirable material like stones, bricks, broken bottles, etc., from the organic manure found in town refuse dumps. The machine being quite simple in design, no patent was taken out for this device.

(xi) Museum of Agricultural implements and organisation of a Tractor Testing Station

On the basis of the recommendations made by the Planning Commission, the Government of India have accorded sanction to the establishment of a Museum of Agricultural Implements and a Tractor Testing Station at this Institute. The purpose of the Museum will be to collect implements from different parts of the country and make them available in a central place for inspection and selection by farmers, implement makers and officers of the Agricultural Departments. Arrangements for organising this museum and the Tractor Testing organisation are making satisfactory progress.

(xii) Visitors

As in previous years a large number of distinguished Indians and foreigners, besides the Members of the Parliament and high officials of the Central and the State Governments, visited the Institute during the year under report. Of these a special mention may be made of the following :—

Members of the Burmese Delegation including the members of the Burmese Planning Commission ; Dr. Shiroshi Nasu, Agricultural Expert, Tokio University ; His Excellency Mr. J. M. A. M. Luns, Minister for Foreign Affairs, Netherlands ; Members of the Thailand Delegation ; Mr. F. T. Wallen, Director of Agricultural Division, Food and Agriculture Organization, Italy ; His Excellency the Ambassador of Soviet Russia in India ; the members of the United States of America Delegation ; Professor W. Riddet, Director, Dairy Research, New Zealand ; Professor and Mrs. Julian Huxley ; Professor F. J. M. Stratton, F.R.S., Cambridge ; Professor F. G. Bawden, F.R.S., Rothamsted Experimental Station ; Professor E. B. Chain, F.R.S., Co-discoverer of Penicillin ; H.H. the Maharaj Kumar of Sikkim ; H.H. the Maharaja and the Maharani of Bhutan ; the Honourable Sir John Kotelawala, Prime Minister of Ceylon and others.

PART II

REPORT OF THE HEADS OF DIVISIONS FOR 1953-54

REPORT OF THE DIVISION OF AGRONOMY (including AGRICULTURAL SUB-STATION, KARNAL) FOR THE YEAR 1953-54

(DR. T. J. MIRCHANDANI)

During the year under report, the research activities of the Division at New Delhi were under the following heads: weather and its effects on crops, manurial experiments, cultural and cultural-cum-manurial experiments, rotation and mixed cropping experiments, varietal-cum-manurial trials, varietal trials, agrostology, irrigation experiments, agronomic experiments on wheat rusts, T. C. M. fertilizer experiments and collaborative experiments.

I. Weather and its effects on crops

The records of the meteorological observations are summarised below:—

Month	Temperature °F				Relative humidity at 7 a.m. (local)	Rain-fall in inches	Dep. from normal	Mean wind velocity in M.P.H.	Mean hours of bright sunshine	Mean evaporation in inches per day
	Mean Max.	Dep. from normal	Mean Min.	Dep. from normal						
1953—										
July	93.4	—2.4	79.5	—1.1	84.1	10.17	+2.68	4.21	5.21	0.2935
August	89.8	—2.4	77.8	—1.2	88.1	5.52	+0.40	4.11	6.20	0.2284
September	93.6	+1.0	76.3	—1.7	79.4	0.41	—4.99	2.50	8.56	0.2740
October	93.7	+2.0	61.6	—2.0	66.8	0.07	—0.33	2.24	9.61	0.2931
November	82.7	—0.1	48.6	—1.5	68.0	0.00	—0.05	2.02	9.33	0.2006
December	77.4	+4.6	47.5	+4.7	85.1	0.00	—0.08	1.87	8.63	0.1254
1954—										
January	66.6	—2.7	41.9	—1.4	86.5	1.17	+0.45	3.13	7.64	0.1138
February	72.1	—2.4	51.2	+4.8	94.3	3.67	+2.98	3.00	6.73	0.1302
March	84.2	—0.1	54.7	—0.5	76.9	0.46	—0.50	3.15	8.47	0.2402
April	99.3	+2.1	64.8	—2.2	42.2	0.00	—0.37	3.23	9.85	0.4622
May	108.1	+3.8	76.4	—0.9	30.2	0.74	+0.32	3.97	10.64	0.5790
June	106.4	+2.1	82.5	+0.2	55.3	0.25	—1.43	5.72	8.50	0.5936

The monsoon broke towards the end of June 1953. The monsoon rainfall from June to September amounted to 19.5 inches, while the winter rains were 5.30 inches. The warm and humid weather prevailing in July induced Jassid attack in cotton and stem-rot in jute. September was comparatively dry which necessitated irrigating all *kharif* crops. In December, the temperature was above the

normal, which caused early earing in wheat N. P. 718 and N. P. 775. Droughty conditions in December again necessitated irrigating all *rabi* crops. There was ground frost for 10 days in January. Severe frost on 21st, 22nd and 23rd January affected the potato and berseem crop adversely. Rainfall in February and March followed by strong wind caused extensive lodging in wheat, oats and barley, which lowered their yields. The yield of gram was adversely affected by wilt. Light showers in May retarded the *rabi* threshing operations.

The yields of principal crops grown during the year under report are given below :—

Crop	Area	1953-54	1952-53
		Yield/acre md.	Yield/acre md.
Wheat	106.89	16.66	18.90
Oats	55.25	18.44	18.60
Barley	4.63	20.93	26.60
Peas	21.98	15.45	11.30
Gram	12.20	5.56	6.58
Maize	34.44	12.19	12.10
Sugarcane	11.40	479.17	337.35
Berseem green fodder	16.75	485.42	571.90

A comparative statement of costs of irrigation during 1953-54 and the past two years is given below :—

Year	Irrigation charges paid Rupees	Area Irrigated Acres	Irrigation cost per acre Rupees
1951-52	1963.90	94543.12	48.14
1952-53	1651.98	89202.86	53.99
1953-54*	1413.23	65922.50	46.50

* Excluding figures for February and March 1954 for which bills have not been received.

II. Research Projects

1. MANURIAL EXPERIMENTS

(i) *Building up of soil fertility through organic manures and inorganic fertilizers with and without legume in rotation.*—The experiment was restarted in 1952-53 and the first cycle of the rotation was completed this year. The results were not significant, except for maize in the cereal rotation where castor-cake, NP, NPK and F. Y. M. showed significantly better results than the control (14.0 to 17.7 mds. as against 11.6 mds./acre for control).

(ii) *Relative value of kharif legumes for green manuring wheat.*—The experiment was concluded this year after conducting it for three years. The results are given below :—

G. M. crops	Average of three years Wheat N. P. 718 md./acre		
	P ₀	P ₁	Av.
A. Guar	21.39	24.59	22.99
B. Sannhemp	22.64	22.25	22.45
C. Cowpeas	21.08	20.03	21.93
D. Soybean	21.03	20.30	21.06
E. Dhaincha	21.83	22.02	20.67
F. No green manure	16.84	16.87	16.85
Average	21.18	20.80	..

'F' test sig. for G. M. treatments only.

C. D. (5%) = 2.44.

All the green manure crops gave significantly higher yields than the control. Differences among the legumes were not significant. The effect of P₂O₅ at 80 lb. per acre applied to legumes was also not significant.

(iii) *Economics of green manuring.*—In this experiment wheat is being grown after different *kharif* crops to compare the results with that of wheat after sannhemp green manuring. The results show that the yield of wheat after green manuring has been significantly higher than that after other crops. The economics of growing wheat after green manure and of double cropping will be known after the experiment is concluded.

(iv) *Green manuring experiment on wheat.*—The experiment has been concluded this year after conducting it for four years. The results obtained in 1953-54 are given below :—

Yield of wheat N. P. 737 in mds./acre					
	P ₂ O ₅ at 80 lb./ acre	N. at 15 lb./acre	N+P	Control	Mean
Sannhemp buried after 4 weeks' growth	18.74	15.62	19.04	15.07	17.12
Sannhemp buried after 6 weeks' growth	20.75	18.10	20.22	15.39	18.61
Sannhemp buried after 8 weeks' growth	23.07	19.33	22.61	19.89	21.23
Sannhemp buried after 10 weeks' growth	18.09	15.05	19.89	16.32	16.89
Mean	20.15	17.02	20.00	16.67	..

'F' test sig. for main effects and interaction.

C. D. (5%) for G. M. = 1.93.

C. D. (5%) for fertilizers = 1.08.

C. D. (5%) for interaction = 2.92.

The above results confirm those obtained in previous years. Sannhemp buried after 8 weeks' growth gave best results.

(v) *Response curve of nitrogen with wheat N. P. 718.*—The results showed increase in yield up to 90 lb. N per acre.

(vi) *Response of ammonium sulphate and F. Y. M. at different levels.*—This is the first year of the experiment. The results indicated that the value of F. Y. M. lies between 20-25 per cent of ammonium sulphate. The soil fertility building value of F. Y. M. as compared to ammonium sulphate will be studied with the progress of this long term experiment.

(vii) *Building up of soil fertility through organic and inorganic manures.*—The second cycle of the rotation G. M.-wheat-maize-wheat was completed this year. The results showed that the after effects of organic manures, including green manure and fertilizers applied in the first year do not persist after the first crop of wheat was taken.

(viii) *Plant composition as an index of fertilizer requirement.*—The experiment was concluded this year. The yield results of maize showed significant effect of nitrogen at 80 lb./acre (31.8 md./acre) followed by 40 lb./acre (23.3 md./acre) and control (11.8 md./acre). The effect of P_2O_5 and K_2O was not significant. The internal plant composition studies are in progress.

(ix) *Effect of low doses of phosphate on berseem and after effects on wheat.*—The second cycle of the rotation, berseem-cowpeas (3 years) followed by wheat after fallow and cowpeas (3 years) was completed this year. The results showed that berseem manured with 64 lb. P_2O_5 /acre, either as F. Y. M. or superphosphate or mixture of superphosphate and F. Y. M. in previous three years, built up soil fertility, as reflected by the high yields of wheat obtained in the same plots in subsequent three years, without manuring (19.4 to 21.6 md. as against 18.7 md./acre for the control).

(x) *Phosphate manuring of berseem with and without potash and/or nitrogen and residual effect on subsequent crops.*—Highest yields of berseem were given by NPK and NP treatments (1,060 and 1,023 md./acre respectively). The effect of potash was not significant, but addition of N to phosphate gave significantly higher yields (1,023 md./acre) than phosphate alone (993 md./acre). As regards residual effect on cotton and wheat, all the phosphate treated plots gave significantly higher yields than the control.

(xi) *Effect of sodium nitrate and ammonium sulphate on sugarcane and cotton.*—The differences between these two types of nitrogenous fertilizers were not significant.

(xii) *Effect of organic and inorganic nitrogenous manuring of bajra and wheat.*—Bajra grown after fallow gave significantly higher yields (20.2 md./acre) than bajra grown after wheat (14.9 md./acre). As regards different doses of F. Y. M., no significant differences were observed. Differences among the levels of nitrogen, 0, 20, 40 lb./acre as ammonium sulphate were significant (15.9, 17.3 and 19.4 md./acre). The interactions were not significant. The wheat crop was badly affected by lodging. Wheat yields after fallow (25.7 md./acre) were significantly better than those after bajra (6.9 md./acre). The results with F. Y. M. and ammonium sulphate were same as given for bajra. The results so far obtained have not indicated the possibility of attaining the objective stated above

2. CULTURAL AND CULTURAL-CUM-MANURIAL EXPERIMENTS

(i) *Cultivation-cum-manurial experiment in a rotation of maize-berseem-fallow-wheat.*—In general, no significant differences were observed between shallow and deep ploughing over a period of four years. There is, therefore, no economic advantage in incurring extra expenditure on deep ploughing. The interaction between cultivation and manurial treatments was not significant.

(ii) *Cultural experiment on cotton.*—Two varieties, viz. F. 216 and M. 4 gave significantly higher yields than F. 320. As regards dates of sowing, June sown crops (11.7 md./acre) gave significantly lower yields than April and May sown crops (16.7 and 15.3 md./acre). Differences among spacings, $1\frac{1}{2}$ ft., 2 ft., and $2\frac{1}{2}$ ft. between rows were not significant, though close spacing indicated better results.

(iii) *Tillage experiment on wheat.*—The experiment was concluded this year after being conducted for four years. The results showed that nine ploughings with country plough, under irrigated conditions, gave best yields of wheat (16.6 md. as against 11.0 to 14.6 md./acre).

(iv) *Cultural experiment on maize.*—The experiment was also concluded this year after conducting it for three years. Sowing maize on 10th July gave better results (18.7 md./acre) than early sowing (14.8 md./acre). As regards earthing and fractional application of fertilizers, the differences were not significant.

(v) *Cultivation experiment on cotton.*—The differences between deep and shallow ploughings were not significant.

(vi) *Cultural experiment on jute.*—For fibre production, March and April sowings gave best results. As regards variety, 0-40-753 proved superior to D. 154.

(vii) *Cultural experiment on wheat.*—Differences among seed rates : 50, 75 and 100 lb./acre and cultural operations : hand weeding, chemical weedicide (Fernoxone) and no weeding, were not significant. Nitrogen level, 40 lb. per acre as ammonium sulphate gave significant differences over 20 lb. N/acre. Interactions were not significant.

(viii) *Cultural-cum-manurial experiment on sugarcane.*—Calcium nitrate gave significantly better results (568 md./acre) than ammonium sulphate and Chilian nitrate. As regards levels of N, 40, 80, 120 lb./acre and weedicides 2-4 D and copper sulphate, the differences were not significant.

(ix) *Cultivation-cum-manurial experiment on potato and carrots.*—With a tuber crop of potato, the differences between deep and shallow ploughings were not significant. But with a root crop of carrots, these treatments showed significant differences in favour of deep ploughing. A well balanced fertilizer mixture 80-80-40 gave good results with both these crops.

(x) *Cultural-cum-manurial experiment on potato.*—The experiment has been concluded this year after conducting it for three years. With *Phulwa* variety of potato, 14th October and 5th November plantings gave significantly better results than September 25 planting. Spacing of $1\frac{1}{2}$ ' and 2' gave significantly higher yields than $2\frac{1}{2}$ ' spacing between rows. As regards time of manuring, applying the whole quantity at planting proved superior to applying in two doses and three doses at earthing.

3. ROTATIONAL AND MIXED CROPPING EXPERIMENTS

(i) *Comparative effect of different rotations.*—Results are available after the completion of one cycle of rotation. The experiment is in progress.

(ii) *Mixed cropping experiments.*—Two experiments were conducted with different mixtures of wheat, peas, linseed and gram. None of the mixtures showed significantly higher yield than that of the pure crops.

4. VARIETAL-CUM-MANURIAL EXPERIMENTS

(i) *Sugarcane.*—Differences among the varieties Cos. 312, 647, 739, 659, 797 and B. O. 11 were not significant. The effect of nitrogen levels was not marked, as the field carried berseem before sugarcane and also manured with 10 tons of F. Y. M. The interaction was not significant.

(ii) *Barley.*—The experiment was concluded this year. Unlike the results obtained in 1951-52 and 1952-53, the differences among the N levels 0, 20, 40 were not significant. This year, P_2O_5 levels 0, 30, 60 showed significant differences (24.6, 25.5 and 26.1 md./acre). Barley variety N. P. 13 gave better yields than K. 251 (26.3 md. and 24.4 md./acre respectively).

(iii) *Potato.*—The experiment was also concluded this year. D. R. R. gave significantly higher yields than Simla Special and Phulwa. The yields showed an increase up to the level of 160 lb. N/acre, after which the yield declined.

5. VARIETAL TRIALS

Among pungent chilli varieties, N. P. Hyb. 5-1—5 gave best results consistently for the last 3 years. Bajra Pb. T. 55 and Bombay 207 showed highest yield of grain. In cotton, M. 4, F. 216, F. 216/14, F. 23, B. C. 68 and 0-394 gave good yields of *kapas*. Hybrid maize Dixie 22, Dixie 33, N. Carolina 27 and U. S. A. 13 gave as good yields as Kanpur 41. Sugarcane Co. 944, Co. 951 and Co. 958 proved promising among the new varieties received from Coimbatore.

6. AGROSTOLOGY

Among grasses, *Brachiaria brizantha*, *Setaria sphacelata*, *Urochloa mosambicensis*, *Urochloa* sp. and *Brachiaria mutica* gave high yield of forage. *B. mutica* yielded 2,133 md./acre in seven cuttings under sewage irrigation. This grass is suitable for saline and water-logged soils. Of legumes, *Lupinus termis*, *Phaseolus lathyroides*, *Desmodium purpureum*, *D. scorpius*, *D. cephalotus* and some of the *Trifolium* species showed promise.

Preliminary tests showed that maize can be grown successfully without manuring after wheat-Huban clover mixture. The yields of wheat and maize were 15 md. and 18.6 md./acre, respectively with three cuttings of clover, two for forage and the last one for green manuring.

(i) *Ley farming experiment.*—The experiment was conducted during the year under report. The yields of wheat and maize after the ley were significantly higher than the control plot yields having cereal rotation of maize and wheat.

(ii) *Fertility building value of soybean.*—The experiment was concluded this year. The results showed that early maturing soybean grown for grain and fodder

depressed the yields of the following wheat crop considerably. Green manuring with soybean also did not show encouraging results.

7. IRRIGATION EXPERIMENTS

(i) *Berseem*.—Fourteen irrigations, each of 3" depth gave significantly better results (989 md./acre) than 10 irrigations (927 md./acre). Effect of fertilizers was not significant, but the trend was in favour of mixture of N and P over P alone.

(ii) *Sugarcane*.—Irrigating at intervals of 10 and 12 days gave significantly higher yield of cane (748 and 784 md./acre) than irrigating after 7 days' (695 md./acre) interval. Further, deep ploughing showed significantly better results (768 md./acre) than shallow ploughing (713 md./acre). As the field carried berseem preceding sugarcane and also manured with F. Y. M., the response to nitrogen was not significant. The interactions were also not significant.

8. AGRONOMIC EXPERIMENTS ON WHEAT RUSTS

Experiments were conducted both at the I. A. R. I., New Delhi and the B. S. S., Pusa to study the effect of agronomic practices, *viz.* dates of sowing, effect of N, P and K fertilizers at different levels and combinations, irrigation and mixed cropping, on the incidence and intensity of wheat rusts. Observations taken in collaboration with the Division of Mycology showed that none of these practices had significant effect on the incidence and intensity of rusts at Pusa. At New Delhi, in plots receiving high dose of NPK and N, the intensity of rust was greater than that in plots treated with lighter dose of fertilizers and no manure. In irrigation experiment, a larger percentage of plant infection was noticed in plots which were given three irrigations and 40 lb. N/acre.

9. T. C. M. FERTILIZER EXPERIMENTS

(i) *Levels and types of nitrogen and levels of phosphorus on wheat*.—There was no significant differences among the types of fertilizers, *viz.* ammonium sulphate, ammonium nitrate and urea. Among levels of N and P_2O_5 , 40 and 20 lb. N/acre and 40 lb. P_2O_5 /acre gave significantly higher yields than the control. The interactions were not significant.

(ii) *Time of application of N fertilizers on wheat*.—As in the above experiment, differences among the types of fertilizers were not significant. Applying fertilizer at sowing or with first irrigation also did not show significant differences.

(iii) *Fertilizer placement experiment on wheat*.—There was no significant differences among types of phosphates, *viz.* superphosphate, nitrophosphate and ammonium phosphate; levels of P_2O_5 , 15 and 30 lb./acre and method of application, broadcast and placing $2\frac{1}{2}$ " below the seed.

(iv) *Irrigation-cum-nitrogen and P_2O_5 levels on wheat*.—Two and three irrigations gave significantly higher yields than one irrigation. 40 and 20 lb. N/acre and 40 lb. P_2O_5 /acre showed significantly better yields than the control. The interactions were not significant.

10. AGRONOMIC EXPERIMENTS AT PUSA

(i) *Permanent manurial and rotation experiment.*—The results are given below :—*Yield of grain per plot in lb. ($\frac{1}{4}$ acre plot)*

Treatment per acre	A SERIES		B SERIES		
	Maize	Wheat	Maize	Peas	Barley
1. No manure (Check No. 1)	82.5	53.0	27.0	26.0	..
2. F. Y. M. 4,000 lb	148.0	96.0	101.0	83.0	..
3. F. Y. M. 8,000 lb	150.0	203.0	47.75	151.5	..
4. F. Y. M. 4,000 lb, rapecake 20 lb N	162.0	183.0	126.0	115.0	..
5. Rape-cake 40 lb N	140.75	141.0	81.0	46.0	..
6. Amm. sulph. 40 lb N	94.0	50.0	37.0	23.25	..
7. Pot. sulph. 50 lb K_2O	56.0	62.0	40.0	35.5	..
8. Super. 80 lb P_2O_5	141.0	74.0	90.0	40.25	..
9. Super. 80 lb P_2O_5 +pot. sulph. 50 lb K_2O	152.0	114.0	128.0	66.5	..
10. Amm. sulph. 40 lb N+super. 80 lb P_2O_5 + Pot. sulph. 50 lb K_2O .	157.0	180.0	132.0	85.0	..
11. Amm. sulph. 40 lb N+super. 80 lb P_2O_5	137.0	106.0	134.0	89.0	..
12. Green manuring in conjunction with a purely cereal rotation.	Green manure	68.0	Green manure	..	40.0
13. No manure (Check No. 2)	45.0	26.0	38.0	32.50	..
14. Amm. sulph. 40 lb N+pot. sulph. 50 lb K_2O	85.0	46.0	34.0	25.0	..
15. Effect of green manure and a legume crop in rotation.	Green manure	107.0	43.5	26.0	..
16. As in No. 15+super. 80 lb P_2O_5	Do.	211.0	26.31	121.5	..
17. No leguminous crop and No G. M.	17.13	30.63	3.69	..	36.0
18. No manure (Check No. 3)	11.5	66.0	Failed due to water logging	36.0	..

(ii) *New manurial experiment.*—The results of this experiment were as follows :—

Treatment/acre	MEAN YIELD OF GRAIN IN MD/ACRE	
	Maize	Peas
A. No manure	3.35	7.34
B. F. Y. M. 40 lb N	5.68	14.79
C. Rape-cake 40 lb N	6.95	11.79
D. Amm. sulph. 40 lb N	4.69	7.71
E. Pot. sulph. 50 lb K ₂ O	3.02	7.86
F. Super. 80 lb P ₂ O ₅	3.94	10.41
G. Super. 80 lb P ₂ O ₅ +pot. sulph. 50 lb K ₂ O	3.28	9.27
H. Amm. sulph. 40 lb N+super. 80 lb P ₂ O ₅ +pot. sulph. 50 lb K ₂ O	5.89	10.46
I. Amm. sulph. 40 lb N+super. 80 lb P ₂ O ₅	5.17	10.62
J. Amm. sulph. 40 lb N+pot. sulph. 50 lb K ₂ O	3.83	7.65
‘ F ’ test		
	Sig.	Sig.
C. D. (5 per cent)	1.39	2.07

In the case of maize, highest yields were given by rape-cake, NPK and F.Y.M. With peas, F.Y.M., rape-cake, NP, NPK and P showed good results.

(iii) *Field experiment to determine the nutritional requirement of the Pusa soils.*—Micronutrients viz. Zn, Mn, Cu, Fe, Mg, Bo and Mo were applied both as soil application and as spray on paddy, singly and in combination, together with and without NPK treatment. The results showed that the micronutrients had no significant effect on the yield of paddy (no manure : 30.1 md ; micronutrients with NPK : 42.9 to 48.0 md and NPK : 43.0 md/acre).

11. Collaborative experiments

(i) *Collaborative work with States.*—Work on the relative value of Chilean nitrate and sulphate of ammonia remained in progress in most of the States at 144 centres. The experiments are being conducted in almost all types of soil in different climatic regions and with all principal crops. The results are being written up in the form of a report.

(ii) *Experiments in collaboration with the Division of Chemistry.*—Compost manures prepared by different methods viz. plastered trench, overground heap and exposed pit were tested in a field experiment on maize and wheat. The differences among the manures were not significant. In another experiment the effect of burying wheat straw with and without nitrogenous fertilizer was studied on the yield of wheat. Here too, the response was not significant as compared to the yields obtained from plots in which wheat straw was not buried.

12. Schemes

(i) *I. C. A. R. Grass Scheme*.—The scheme for the collection of indigenous and exotic grasses and legumes, their testing and distribution, which came into operation in February, 1953, continued to function.

(ii) *I. C. O. C. Oilseed Scheme*.—The work on varietal trials, mixed cropping and manurial experiments on sesamum and linseed remained in progress.

III. Seed Distribution

Seeds of improved varieties of crops were distributed as given below :—

Crop	Quantity (md.)
Wheat	908.33
Oats	65.95
Barley	24.31
Maize	41.11
Cowpeas	7.78
Soybean	1.84
Other crops	10.56
Grasses and legumes	1,738 seed samples
Kudzu vine	1,089 crowns and 82 potted plants.

IV. Farm Economics

Cost studies have been the main work of this Section. The working cost of a pair of bullocks was worked out for the year 1952-53. The overall cost for farm bullocks was Rs. 6-9-6 per pair per working day. The cost of maintenance (including fodder and feeds) and the cost of fodder and feeds alone worked out to Rs. 2-1-0 and Rs. 1-8-3 per bullock per day respectively.

On the Dairy side, the cost of production of milk was calculated for the year 1952-53. The net total cost was Rs. 61,185, and the total milk yield was 121,422½ lb. Thus the average cost per lb of milk for the year worked out to as. 0-8-1.

V. Intensive Cultivation Scheme

The agronomic work under the Scheme in the nineteen villages which began on August 2, 1950, showed considerable progress during the year under report. The total number of demonstrations with new varieties, commercial fertilizers and manures and improved cultural practices was 479 as against 244 in 1952-53 and 311 in 1951-52. Two N. P. wheat varieties viz. 718 and 775 have become very popular with cultivators: the area saturated with N. P. 718 alone has reached 232 acres. Oats N. P. 1, barley N. P. 13 and gram N. P. 53 have also become popular with cultivators. Green manuring has shown an average increase of about 5 md.

acre of wheat grain over the control. The highest yield of paddy under the Japanese method of cultivation was 65.43 md/acre.

VI. Key Village Scheme

The work under this Scheme started in March, 1954, with the appointment of the Veterinary Assistant. A census of livestock population in the nineteen villages under the Intensive Cultivation Scheme was taken. The total number of cows and buffaloes of breeding age (over three years) in these villages was found to be 3,257.

VII. Cattle Breeding and Management

(i) *General*.—The strength of the Sahiwal herd on the 30th June, 1954 was 53 as against 54 at the close of the last year. The herd consisted of 22 cows, 3 stud bulls, 9 young male stock, 10 young female stock, 2 male calves and 7 female calves. The animals in general maintained good health. Foot-and-mouth disease appeared in the herd in March, 1954 and was responsible for the death of four pail-fed calves.

(ii) *Milk yield*.—The wet and overall averages during the year under report were 23.1 and 13.5 lb respectively. Out of 11 cows which completed their lactations during the year, 2 did over 10,000 lb, 3 over 9,000 lb and 2 over 8,000 lb per lactation. One heifer did over 8,000 lb in her lactation.

(iii) *Calf rearing*.—Nine male and eight female calves were born during the year. Their average birth weights were 61.2 lb and 56.2 lb respectively. There were five deaths among the pail-fed calves, out of which four died of foot-and-mouth disease. The growth rate was 1.4 lb per head-day both for the male and the female calves.

(iv) *Early maturity experiment*.—One early maturity heifer completed her lactation during the year under report. The performances of the early maturity cows and heifers are given below :—

Description of cattle	No.	Age at 1st calving	Average milk yield per lactation (lb)		
			I	II	III
		Y. M. D.			
First calvers	1	2 7 19	8,856	..	..
Second calvers	1	2 7 1	5,939	6,852	..
Third calvers	9	2 5 21	6,421	6,927	7,715

As expected, the yields of the second and the third calvers improved in the subsequent lactations.

(v) *Sale of cattle*.—Three cows, six young male stock and one bull were sold during the year under report for Rs. 5,661.

VIII. Statistical Section

As in previous years the Section attended to a large volume of work in the designing of field experiments for new research projects and in the analysis of a

large number of current experiments from the various Divisions. Besides teaching of post-graduate and Central College of Agriculture students and advisory work, the lengthy data on twelve different long-term experiments received from various Divisions of the Institute like Wheat Varieties Trial conducted at 30 different centres for a number of years, etc., were statistically examined and results of the statistical analysis sent to them.

A crop cutting survey—1953-54 under I. A. R. I. Intensive Cultivation Scheme was also conducted to determine the best form and dose of nitrogenous fertilizers among ammonium sulphate, ammonium nitrate and urea, used at 0, 20 and 40 lb N per acre. A sample cut each of size 33'×16.5' was taken at random from differently manured plots in six villages viz. (i) Nilothi, (ii) Bapraulla, (iii) Budhela, (iv) Hastal, (v) Qamrudin Nagar and (vi) Ranhola, and the data subjected to statistical analysis. From the results of the statistical analysis it was observed that there was no significant difference in the forms of fertilizers with respect to 20 lb of N, but the dose of 40 lb N as ammonium sulphate gave significantly the best result.

IX. Programme of work for 1954-55

A. Manurial Experiments

(i) Nitrogenous manures and fertilizers : Experiments to test the relative values of nitrogen in organic and inorganic manures and also response of their combination on various crops. Experiments to determine optimum time for the application of farmyard manure and nitrogenous fertilizers.

(ii) Phosphatic fertilizers : Experiments with different forms of phosphatic fertilizers to study their response.

(iii) Nitrogenous and phosphatic fertilizers : Experiments to study the effect of these, each at different levels and in combinations on the yield of different crops.

(iv) Green manures : Green manuring experiment with guar in conjunction with micronutrients ; economics of green manuring.

(v) Manurial-cum-cultural experiments with various crops involving studies on manuring in relation to sowing dates, seed rates, time of application and placement.

(vi) Micronutrient studies.

(vii) Permanent and new manurial experiments at Pusa under rain-fed conditions.

B. Cultural Experiments

(i) Tillage experiments with different crops.

(ii) Sowing dates, placement, weedicides, seed rates and spacing experiments with various crops.

C. Rotation Experiments

To study the effect of different intensities, legumes, fallow and sequence of cropping.

D. Varietal Trials

Experiments will be conducted with improved varieties of different crops.

E. Irrigation Experiments

(i) Experiment to study the relationship of irrigation, variety and nitrogen in case of wheat. (ii) Irrigation, cultivation and nitrogen in case of sugarcane.

F. Agrostology

To produce high yielding and palatable fodder grasses and legumes for cattle ; increase the productivity of natural grassland ; to work out suitable seed mixtures of grasses and legumes for pastures ; to evolve a suitable system of ley farming ; maintenance of nursery.

G. Collaborative Research in States

On grasses and legumes and Chilean nitrate.

H. Experiment in connection with T.C.M.

(Technical Co-operation Mission).

I. Model Agronomic Experiments**J. Cattle Breeding and Management**

It will include work on :—

- (i) Line breeding and selection for improvement in milk yield.
- (ii) Feeding of stock on balanced rations for growth, early maturity and high milk yield.

K. I.A.R.I. Intensive Cultivation Scheme

The intensification work in the 19 villages around the Delhi State will be continued.

L. Key Village Scheme

Improvement of cattle and buffaloes in the 19 villages.

AGRICULTURAL RESEARCH SUB-STATION, KARNAL

The total area of the Substation is 180.12 acres. The main activities of the Substation were to (i) carry out large scale field experiments on different aspects of agronomic research, (ii) multiply and distribute seeds of improved strains of field crops and (iii) render assistance to the different Divisions of the Institute in carrying out their field experiments.

I. Weather and its Effect on Crops

The total rainfall from 1st June, 1953 to 31st May, 1954 amounted to 36.18 inches. The rainfall was above the normal which is 25.89 inches.

The rainfall during the year under report was not evenly distributed. The weather in the second fortnight of December remained warmer than the normal.

This was responsible to some extent for the early flowering of wheat sown in the month of October. Ground frost was recorded on six consecutive days from 21-1-54. The hailstorm of 16th February 1954 caused severe damage to the crops in general and wheat in particular. Wheat and oat crops also lodged heavily. The major disease in wheat was rust and bunt. The infection of all the three rusts ranged from moderate to heavy in various varieties.

The yields of the principal crops grown on the farm are given below :—

Crop	Yield per acre
	Md.
Paddy	29.2
Maize	20.2
Wheat	14.3
Barley	22.2
Gram	14.2
Pea	10.7
Berseem (fodder)	937.5

II. Research Projects

1. MANURIAL EXPERIMENTS

(i) *Paddy*.—Green manuring with *dhaincha* with or without phosphate produced significantly higher yield than ammonium sulphate which in turn proved significantly superior at 40 and 20 lb N per acre to 'no manure'.

Nursery manuring at 1,000 and 2,000 maunds of F. Y. M./acre did not produce significant effect. However, field manuring at 40 lb N as ammonium sulphate proved significantly superior to 40 lb N per acre as F. Y. M.

Three forms of nitrogen viz. ammonium sulphate, ammonium sulphate nitrate and ammonium chloride at 20 lb N/acre did not differ among themselves, but were significantly superior to 'no manure'.

Ammonium sulphate at 40 lb N/acre proved superior to 20 lb N per acre which was better than 'no manure'. F. Y. M. at 20 cartloads was at par with 10 cartloads, but significantly superior to 'no F. Y. M.'. Superphosphate at 20 to 40 lb P_2O_5 /acre gave significantly higher yield than 'no phosphate'.

Minor elements did not show significant response. However, the interaction manganese sulphate X sodium molybdate was found to be significant.

In a paddy-wheat rotation, 30 or 60 lb N/acre as ammonium sulphate produced significantly superior yield to 'no nitrogen'. 60 lb and 120 lb P_2O_5 /acre proved significantly better than 'no phosphate'. The interaction between N and P was also significant. The succeeding crop of wheat gave significantly higher yield at 30 and 60 lb N/acre than 'no nitrogen'. The effect of phosphate, direct or residual, was not significant.

(ii) *Wheat*.—Three forms of nitrogen viz. ammonium sulphate, ammonium sulphate nitrate and ammonium chloride at 20 and 40 lb N/acre were at par among themselves and were significantly superior to 'no manure'.

Ammonium sulphate at 40 and 20 lb N/acre did not differ between themselves but were significantly superior to 'no nitrogen'. Similarly 20 cartloads were at par with 10 cartloads and significantly superior to 'no F. Y. M.'. The effect of phosphate was not significant.

Minor elements did not show significant results.

Residual effects of organic, inorganic and minor elements applied to paddy, on subsequent crop of wheat, were not significant.

2. VARIETAL TRIALS

In the jowar varietal trial C. 10-2, J. C. 20 and J. C. 21 produced the highest yields. Among the fourteen varieties of wheat, N. P. 718 proved to be the best. This was followed by N. P. 798, N. P. 797, N. P. 799, N. P. 721 and C. 591. Linseed varieties R. R. 45, R. R. 236 and R. R. 272 produced superior yields. Among the cotton varieties, F. 320 gave the highest yield and this was followed by F. 216/14, F. 216/17, F. 216/3 and F. 216.

3. CULTURAL EXPERIMENTS

Experiment to test the merits of seed bed preparation with tractor plough and bullock drawn inversion-*cum*-non-inversion ploughs for wheat did not show any difference between the cultural operations. In another experiment with paddy, no significant difference was observed in yield among broadcasting, drilling of seeds and transplanting of seedlings.

III. Seed Supply

Seeds of improved varieties of crops were distributed. The total quantity supplied was about 489 maunds.

IV. Programme of work for 1954-55

Work will be continued on the lines mentioned in the report. The following new items will also be included :—

1. *Experiments under T. C. M. fertilizers scheme—*
 - (i) Time of application of fertilizers on paddy.
 - (ii) Placement of fertilizers on paddy.
 - (iii) N. P. K. experiment on paddy.
2. *Experiment in collaboration with the Chemistry Division—*
 - (i) Soaking of paddy seedlings.
3. *Experiment in collaboration with the Botany Division—*
 - (i) Varietal trial on paddy with ten early and mid-early types.
 - (ii) Varietal trial on paddy with eight late maturing types.



REPORT OF THE DIVISION OF BOTANY (INCLUDING BOTANICAL SUB-STATION, PUSA) FOR THE YEAR 1953-54

(DR S. M. SIKKA)

The research activities of this Division are directed mainly towards devising and testing techniques which make for efficiency in plant breeding, with a view to evolving superior varieties of crop plants. To this end, fundamental researches are also undertaken in the cognate sciences, like plant genetics, cytology, physiology and systematic botany. Special attention is devoted to basic problems of all-India importance, such as breeding for hardiness and resistance to diseases and pests, the problems of resistance to drought and lodging, etc. The research work of the Division continued under the four sections comprising it, viz., (i) Plant Breeding and Genetics, (ii) Cytology and Cytogenetics, (iii) Plant Physiology and (iv) Plant Introduction, Economic Botany and Systematic Botany. During the year under report, work was commenced in the newly-initiated Horticulture Section of the Division as also under the schemes dealing with the die-back disease of citrus and with the breeding of some pasture grasses and legumes.

As in the previous years, collaborative work, mainly involving exchange and evaluation of plant material and scientific information, was done with the State Departments of Agriculture and other research institutions within the country and abroad and with international organisations like the Food and Agricultural Organisation of the United Nations. Several items of advisory work were also attended to.

The results obtained and the main lines of work done in the different Sections of the Division are outlined below.

PLANT BREEDING AND GENETICS

1. Breeding disease resistant wheat varieties

This work is being done at Delhi, Simla, Pusa (Bihar) and Indore under the Co-ordinated Wheat Rust Control Scheme; work at the fifth centre, Wellington (South India), could not be commenced as facilities of land and building are not yet available. The work aims at evolving high yielding, disease resistant, especially rust and smut resistant, wheat varieties suited to the tract in which these centres are located. In addition, the Indore centre devotes attention to the amelioration of *durum* wheats, which are important in that tract, and the Wellington centre to *dicoccums*.

According to the recently-reorientated breeding programme, the work is directed towards bringing in resistance to a particular rust from diverse sources. To this end a number of single, double and multiple crosses and backcrosses involving rust resistant wheats, both indigenous and foreign, and leading Indian varieties have been made. The rust resistant varieties being used in the programme includes N.P. 790, E. 581 (Kenya), E. 572 (Ridley from Australia) and E. 931 (Gaza) for

black rust, E. 957 (Frontiera) and E. 928 (La Prevision) for brown rust and E. 671 (Cometa Klein) for yellow rust.

With the help of the Mycology Division, the reaction of several indigenous and exotic varieties and of progenies of over 800 hybrid combinations was extensively tested, both at the seedling and adult plant stages, under artificial infection with individual races of the three rusts as well as with a mixture of all races. Based on these observations and on those in respect of agronomically desirable characters, large numbers of promising single plant selections have been made at each of the four research centres; those cultures that were selected in the previous years and were now uniform in behaviour were bulked together.

The important data regarding the rust-reaction tests are summarised below :—

The reaction of some exotic wheat varieties to a mixture of thirty races of the three rusts in the adult stage of plant*

Centre	EXOTIC WHEAT CULTURES	
	Total tested	Found resistant
Delhi	177	8 to black ; 86 to brown ; 65 to yellow. 1 to all the three rusts (E. 2564) X 1 to black and brown ; 14 to brown and yellow.
Pusa	450	22 to black ; 59 to brown ; 8 to black and brown.
Indore**	23 durum	2
(Only black rust)	58 vulgare	36

* This year, the new race (122) of black rust was also included in the test.

** Only black rust is of importance in Indore tract.

The reaction of certain exotic and Indian wheat varieties to individual races of the different rusts in the seedling stage

BLACK RUST				BROWN RUST				YELLOW RUST			
EXOTIC		INDIAN		EXOTIC		INDIAN		EXOTIC		INDIAN	
Total tested	Found resistant	Total tested	Found resistant	Total tested	Found resistant	Total tested	Found resistant	Total tested	Found resistant	Total tested	Found resistant
7	E. 2025 to all races.	13	NP. 797 to 10 races.	24	E. 928, E. 957, E. 931, E. 2025, E. 951 and E. 2158 to all races.	18	NP. 788, NP. 798, NP. 803 to 5 races.	15	E. 928, E. 938, E. 952, E. 740, E. 687 and E. 630 to all races.	22	W. 10/S. 67, W. 10/S. 69 to all races.
	E. 871 to 10 races.		NP. 792 & NP. 809 to 9 races.		E. 871, E. 1906 and E. 2083 to 7 races.				E. 671 to 9 races.		W. 9/S. 48 and W. 9/S. 50 to 9 races.
			NP. 788 & NP. 795 to 8 races.								W. 9/S. 51 to 8 races.
											W. 9/S. 49, W. 8A/S. 33, W. 8/S. 35, NP. 788, NP. 809 to 7 races.

Adult plant tests, under artificial infection with a mixture of all the 30 races of the three rusts, have confirmed that N. P. 789 and N.P. 790, especially the latter, are almost immune from black and brown rusts, but are susceptible to yellow rust. N.P. 785 was free from brown and yellow rusts. N.P. 784 was highly resistant to brown and yellow rusts although it went down to black rust. N.P. 801 was highly resistant to all the three rusts.

Yield trials.—With the co-operation of State Departments of Agriculture and Community Projects Administration, yield trials were conducted at about 150 locations, covering the entire wheat tracts of India, with N.P. wheats of proven merit and with some of the newer N.P. strains. The object is to determine their regional suitability as compared to that of the established varieties. In Madhya Bharat, varieties of *durum* were also tested at some centres.

(a) *Trials in the plains.*—Trials conducted during the year under report confirmed previous years' findings that N.P. 710 is suitable for Uttar Pradesh, Madhya Bharat, West Bengal and Saurashtra, N.P. 718 for Delhi and Rajasthan and N.P. 755, N.P. 758 and N.P. 761 for North Bihar. These varieties are tolerant to rusts and highly resistant to loose smut, especially the varieties N.P. 710, N.P. 718 and N.P. 761.

In Uttar Pradesh, N.P. 710 was the topmost variety in all the eight irrigated trials in Jhansi district; at Bara Banki and Rampur it stood first, clearly out-yielding Ph.C. 591, and at Mathura, Nainital and Bulandshahr this year it stood second or third. This variety has also done well at Berhampur, Maldah and Cooch Behar in West Bengal and at Dabra and Indore in Madhya Bharat. In Saurashtra, it gave top yields at two out of four centres. At Basi (Rajasthan) and Cuttack (Orissa), N.P. 718 stood first; at Basi it out-yielded Ph.C. 591 by about 4 mds. per acre.

The demand for seed of all these varieties, especially N.P. 710 and N.P. 718, continues to be too great to be met in full from supplies from this Institute alone. This year, about 3,000 mds. of seed of these improved wheats was produced by the Institute, whereas demands totalling well over 6,000 mds. were received, especially from Orissa, Saurashtra, Rajasthan and Himachal Pradesh; Uttar Pradesh asked for "as much seed as possible" of N.P. 710.

(b) *Trials in the hills.*—Results obtained this year further established the superiority of N.P. 770, Ridley and N.P. 809 in the hills of Himachal Pradesh, Punjab and Uttar Pradesh; seeds of N.P. 770 and Ridley are already being multiplied for distribution in Himachal Pradesh. N.P. 770, a bearded strain with attractive ears and grains, is highly resistant to yellow rust and loose smut and gives very high yields at high altitudes when sown a little late. Ridley is a recently-introduced, black rust resistant, Australian variety having attractive grains. N.P. 809 represents a unique example of planned breeding work leading to the production of an economic variety resistant to all the three rusts; it has long-tipped ears and good grains.

(c) *New promising varieties.*—Some outstandingly promising strains, e.g., N.P. 797, 798 and 799, have been evolved in recent years; they gave outstandingly high grain yield, are highly resistant to loose smut and to all the three rusts at the

adult plant stage and also possess attractive good-quality grains. N.P. 799 gave the topmost yields of 1,977, 1,997 and 1,472 lbs. per acre in trials held, respectively, at Delhi, Patna and Pusa. N.P. 797 and 798 also have done very well at Delhi, Karnal, Indore, Patna and Cuttack.

Durum wheats.—Work on the improvement of *durum* wheat was commenced only recently at Indore where, as a first step, the evaluation of the existing local and improved strains was in progress. At three centres, *viz.*, Indore, Ujjain and Mahagarh, in Madhya Bharat, Alapur 6-1, a selection from the local, has done uniformly well.

World catalogue of genetic stocks of wheat.—This item of work is being done in collaboration with the F.A.O. Detailed tabulated descriptive notes were prepared in respect of 38 Indian wheats and sent to that Organisation. A trial was conducted with 105 varieties collected from different parts of the country and notes on yield and other agronomic characters were recorded on them.

2. Breeding of rust resistant and early maturing strains of linseed

Further selections were made in the progenies of crosses made between the varieties, "Bolley Golden" and "Afghanistan-2" on the one hand and N.P. rust resistant strains on the other; finally, 82 promising, rust resistant isolates possessing earliness together with good tillering and bearing and other desirable agronomic characters have been obtained. Selection for rust resistance was done under artificial inoculation of the disease carried out in the field with the co-operation of the Mycology Division. Tests for resistance in the seedling stage with a mixture of all the physiologic races, as also reaction of a number of strains to individual physiologic races of the rust, were carried out; some cultures showed resistance to or immunity from all the four races and some others to the one or the other race only. Some of the high yielding, rust resistant strains, *e.g.* N.P. (R.R.) 5, 9, 10, 37 and 45, appear to be highly resistant to the wilt disease (caused by *Fusarium lini*) also.

Further selection work was also done in progenies obtained from crosses of the flax variety, "Wada", with N.P. (R.R.) strains, the object being to obtain early-maturing, rust resistant, dual-purpose (for fibre and seed) strains. In a trial conducted at Delhi, the dual purpose strains—(Flax Tall $\times$ N.P.124)-6 and (Flax Tall $\times$ N.P.124)-9, gave the best seed and fibre yields as shown below :—

Variety or strain	Seed yield	Straw yield
	(lbs./acre)	(lbs./acre)
1. (Flax Tall $\times$ N. P. 124)-6	1208.1	3266.9
2. (Flax Tall $\times$ N. P. 124)-9	1140.0	3198.8
3. N. P. 12 (Control-linseed)	1054.9	2450.1
4. Flax Tall—N. C. 5 (Control-flax)	629.5	4628.1

Yield trials of rust resistant strains of linseed were conducted, besides Delhi, at 18 centres. The available results indicate that the strains, N.P. (R.R.) 204, 439 and 38 are very suitable for Delhi, N.P. (R.R.) 440 and 272 for northern Madhya

Pradesh, N.P.(R.R.) 440 in South Bihar and N.P. (R.R.) 38 in Orissa and West Bengal ; N.P.(R.R.) 439 and 440 belong to the newly-bred series of early-maturing, rust resistant strains.

Some of the States have already taken steps to multiply seeds of the rust resistant strains found to be suitable for their respective areas ; *e.g.*, N.P.(R.R.) 5 and 45 in Bihar, N.P.(R.R.) 9, 204 and 262 in Madhya Bharat, N.P.(R.R.) 272 and 267 in Madhya Pradesh and N.P.(R.R.) 45 in Rajasthan.

3. Safflower

In a replicated yield trial at Delhi, the Nebraska strains—Neb. 455-2-6 and Neb. 852, gave 563.1 and 550.4 lbs. of seed per acre as against 498.3 lbs. given by the control, N.P. 1. The Nebraska strains were also under trial at 10 other centres in Hyderabad and Bombay. In Hyderabad, Neb. 455-2-6 outyielded all the local and improved types at Badnapur only. The results from centres in Bombay are still awaited.

4. Pigeon pea

Tests carried out in a wilt-sick plot, confirmed the previous years' findings regarding the high degree of resistance to wilt (*Fusarium udum*) shown by some N.P. types (*e.g.*, N.P. 41, 51 and 80) and hybrid selections (*e.g.*, C. 15 W. E., C. 15 Pusa, C. 38).

A preliminary-row-trial was conducted at Delhi in a wilt-sick plot with some early-maturing, wilt resistant hybrids and some provincial types ; the results are summarised below :—

Strain	Calculated yield	Mortality due to wilt
	(lbs/acre)	Per cent.
N. P. Hyb. 48	2016.7	0.2
Hyderabad C. 36	1749.2	0.8
N. P. Hyb. D. 16-17-2	1661.7	0.5
N. P. C. 15 Pusa	1560.9	0.0
N. P. 41 (control)	1210.0	0.0
Hyderabad C. 28	806.7	0.5
Hyderabad C. 11	552.6	0.4

The wilt resistant strain, N.P. C. 15 Pusa, was found to be consistently superior in the trials conducted by the Director, Sugarcane Research and Development (Bihar), Pusa, who has now taken steps to multiply seeds of this variety for distribution in that tract.

5. Chilli

The yield trials conducted at Delhi and Pusa (Bihar) finally confirmed the superiority of the newly bred pungent strain, N.P. Hyb. 5-15, and also of N.P. 46A; there has been a great demand from growers for seeds of N.P. 46A. Among the non-pungent chillies, the varieties, "Bell Pepper" and R. 449, were again the outstandingly superior yielders.

6. Tobacco (*Nicotiana rustica*)

In a yield trial conducted at Delhi, S. 19 (now designated N.P. 219) maintained the consistently highest yields given by it during the previous years. S. 19 (N.P. 219) and S. 20 (N.P. 220) have now been released for distribution and are in great demand in the Delhi villages.

7. Tomato

The large collection, comprising about 200 exotic and 100 indigenous varieties, was under study; the American variety "Sioux" and the indigenous "Meeruti" remained the most superior ones. Selection work in the progeny of the cross, Sioux $\times$ Meeruti, was in progress; two of the selections, 40.41 and 40.54, appeared to be very promising in that they combined the shape, colour, and quality of fruit of Sioux with hardness, growth habit and medium fruit size of Meeruti. From another cross, Red Cloud $\times$ Meeruti, two early-maturing promising cultures, possessing medium-sized fruits and determinate habit, have been isolated; they are about 5-7 days earlier than Sioux and Meeruti.

Interesting results were obtained in an experiment conducted to test out the performance of various hybrids. The results, which are summarised below, largely confirmed those obtained last year:—

Parent or cross	Average yield of fruit per plant (ozs)	Percentage increase or decrease of yield over superior parent
Sioux	60.50	..
Meeruti	50.50	..
F ₁ (Sioux $\times$ Meeruti)	70.25	+16.1
F ₁ (Meeruti $\times$ Sioux)	74.25	+23.6

With a view to facilitating the production of hybrid tomato seed, four male sterile lines were obtained from the U. S. A. and are being utilised in developing suitable male-sterile lines of Sioux and Meeruti.

Determination of vitamin C and sugar content was carried out on some varieties and hybrids with the co-operation of the Division of Chemistry. A cherry-type of tomato variety collected from Dharwar was found to possess remarkably high vitamin C content of 70.5 mgms. per 100 gms., whereas in none of the cultivated tomatoes was the corresponding value above 40 mgms.

8. Breeding bhindi (*Abelmoschus esculentus*) for resistance to yellow-vein-mosaic

F₁ hybrids of crosses between the variety, "Sabour Selection", on the one hand and the mosaic-tolerant varieties, e.g., I.C. 1524, I.C. 1532 and I.C. 1542 on the other hand were selfed and suitably back crossed; the F₁ hybrids showed susceptibility to yellow vein mosaic. The 5-edged condition of fruit of the resistant types was dominant over the 3-edged condition of Sabour Selection. Homozygous round-fruited selections were obtained from the cross, Sabour Selection $\times$ Green Velvet; the former variety is indigenous and has five-edged fruits and the latter is American and has round fruits which do not shatter their seeds on drying. Some of the selections flowered about 7 days earlier than Sabour Selection; two of them have been further crossed with mosaic-tolerant varieties.

Heterosis was noticed in respect of fruit yield in some F₁ hybrid combinations in *bhindi*, such as B. H. 27 $\times$ B.H. 13, Gwallor $\times$ I.C. 1543, I.C. 1543 $\times$ B.H. 13 and I.C. 1510 $\times$ B.H. 27; the experiment will be repeated next year to confirm these results.

9. Utilisation of hybrid vigour in radish

Last year, four different types of planting of parental varieties were done for finding out the method that will produce a high percentage of genuine hybrid seed. The types of planting were: (i) varieties planted in alternate rows, (ii) varieties alternated in the same row, (iii) zigzag arrangement of varieties in alternated rows and (iv) one variety surrounded by the other on all its sides; the percentage values in respect of genuine hybrids obtained from these plantings were, respectively, 49.2, 48.1, 85.5 and 93.8. The varieties used were the Chinese, T. 323, and the indigenous, "Pahelwan".

10. Improvement of brinjal

A large collection, comprising indigenous varieties, was grown for observation. The variety, *batia*, grown locally in Delhi State, appeared to be very good and seemed to withstand the insect borer; the variety is being purified. The round fruited variety, American Purple 88, obtained from Pozna was the only variety which remained free from various types of virus infection.

11. Jowar and Bajra :

This work was undertaken in the recent years with a view to ascertaining varieties suited for the Delhi tract. In *bajra*, while the variety Baroda 207 did well both with and without artificial irrigation, the varieties U.P.T. 55, Gwallor 2 and Delhi Local did better in the non-irrigated trial. In *jowar*, the variety from Gwallor, viz., Early Prodigy, appeared to be a superior bold-grained variety and those from Indore, viz., I.C. 1505, I.C. 1506 and I.C. 1513, appeared promising as fodder varieties but they were rather late flowering for seed purposes.

12. Hybrid maize :

This work is being done under a scheme financed by the Indian Council of Agricultural Research.

Inbreeding and hybridisation work in Indian material.—The total number of inbreds grown from S_1 to S_4 generations was 540. Further inbreeding was done in them and the desirable inbred lines were selected for further inbreeding and testing in top-crosses; about 240 top-crosses were attempted and sufficient seeds were obtained in 150 lines. Seventy-one inbred lines belonging to the S_5 and later generations of selfing were multiplied and the suitable among them were used in the production of single crosses. Sufficient seeds have been obtained, for testing specific combining ability and for studying the effect of genetic diversity, for 120 single crosses and 20 double and multiple crosses.

Inbred lines from the U.S.A.—Thirty-three inbred lines were grown. They constitute parental lines of some of the American double crosses, e.g., N.C. 27, Texas 26, Dixie 18, etc., which in previous years significantly outyielded local varieties at several centres in India. Of these inbred lines, only 27 could be successfully multiplied and 7 single-crosses were made. With these single crosses, it would be possible to produce double-cross seeds of hybrids like Dixie 18, Texas 26 and Georgia 281.

Top-cross yield tests.—For studying the general combining ability of 88 inbred lines, top-cross yield tests were conducted. The following inbred lines in top-crosses outyielded the control variety, Kanpur T. 41: Georgia 281(51)-1, U. 7(51)-2, 613 LF(51)-4, Ind. 620C(51)-1, 625 MLR(51)-3 and 625 MLR(51)-1.

Yield trials of varieties and hybrids at Delhi.—Two varietal trials, with varieties from within the country and abroad, were conducted at Delhi. The exotic varieties, Venezuela No. 1, Salvadorean Yellow and Jelicose gave top performance. However, these varieties were about 8-10 days later in maturity than the control, Kanpur T. 41, excepting Jelicose which was about 5 days earlier in maturity. The trials will be repeated next year.

A yield trial was also conducted with 18 varietal crosses, along with the parental varieties. The data are summarised below:—

Hybrid	Grain yield (lbs/acre)	Percentage increase over average of parents	Percentage increase over superior parent
Basi × V. H. 49H.309	3,415	49.6	40.2
V.H. 49H. 309 × Pusa Yellow-2	3,332	25.6	23.5
Mulknur × Basi	3,182	25.6	21.3
Bidar × Basi	3,149	13.6	1.6
Mulknur × J. I. 50 Celita	3,049	39.1	16.1

It would thus appear possible to exploit hybrid vigour in certain varietal crosses until superior hybrids are evolved.

At Delhi, a small-scale field trial was conducted with 19 American maize hybrids; the results are summarised below:

Variety or hybrid	Grain yield (lbs./acre)	Days to silk
Dixie 22	4898.0	55.5
Dixie 33 (Pink)	4623.1	52.2
N.C. 27	4598.2	53.5
Dixie 11	4431.2	59.0
Dixie 18	4231.6	59.2
Texas 26	4231.6	54.5
Kanpur T. 41 (control)	3098.8	49.7
Pusa Yellow-2 (control)	2890.5	58.2
C.D. (at 5%)	931.3	4.4

Thus all the above hybrids significantly outyielded the controls.

In a large-scale performance test at Delhi (actual plot size per variety, 0.5 acres), the American hybrid, N. C. 27, gave 61 mds. of grain per acre as compared to 45.5 mds. given by Kanpur T. 41.

Trials of American hybrids at other centres.—Small-scale trials at 24 centres and large-scale trials at 18 centres in India were conducted: results are so far available from 7 of the former centres and 7 of the latter and are summarised below:

Small-scale trials

Centre	Yield of best local (lbs./acre)	Yield of best hybrid (lbs./acre)	Yield of best hybrid as percentage of best local	C.D. (at 5% level)
Delhi	K.T. 41(3098)	Dixie 22 (4898)	158.6	931
Ramapattnagar (Hydrabad)	H.M. 1 (1854)	Ind. 9296 (1674)	77.7	417
Bejwandi (Hydrabad)	Jangpur 576	Florida W. 1(1039)	166.4	S.E.m=59
Karimnagar (Hydrabad)	Local (1343)	Ind. 9994 (1276)	94.6	221
Patiala (PEPSU)	Patiala Local (1124)	Ohio. C. 92 (1504)	133.8	352
Dohad (Bombay)	Farm Sameri (3131)	N.C. 27 (3196)	102.0	768
Mandya (Mysore)	Local-2 (1724)	Dixie 33 (17241)	999.5	..

Large-scale trials

Centre	Yield of best local (lbs./acre)	Yield of best hybrid (lbs./acre)	Yield of best hybrid as percentage of best local	C. D. (at 5% level)
Indore (Madhya Bharat)	Local Sathi White (486)	U.S. 13 (1005)	206.7	..
Sangareddy (Hyderabad)*	Local (329)	Ind. 252A (312)	94.8	53.3
Siddipet (Hyderabad)*	Local (381)	Dixie 22 (327)	85.8	S.E.m = 106.8
Peddapalli (Hyderabad)	H.M.1 and H.M. 2 (190)	Gorgia 281 (316)	166.3	66.5
Dohad (Bombay)	Farm Sameri (4472)	N.C. 27 (4346)	97.1	2385
Arbhavi (Bombay)	(I. 5 × L.5) × S. 23 (2211)	N.C. 27 (2541)	110.4	175
Mandya (Mysore)	Pearl Beauty (2098)	Dixie 33 (13862)	660.7	..

* At Sangareddy and Siddipet, "Meerut Yellow" and K. T. 41 were, respectively, the highest yielders having given grainyields of 425 and 409 lbs. per acre.

It will be observed that the American hybrids gave a very good performance at several locations.

13. Breeding of some pasture grasses and legumes :

Work on this scheme, financed by the Indian Council of Agricultural Research, was initiated during the year under report. The object is to examine the possibilities of producing superior strains of pasture grasses and legumes for northern India. The collection already available at the Institute was critically studied and further additions to it were made. The material on which work was in progress comprised species of *Cenchrus*, *Chrysopogon*, *Pennisetum* and the legume, *Pueraria*. An Australian variety of *Cenchrus ciliaris* was observed to be promising as regards resistance to heat and drought. The extent of seed setting under bagging was studied in the material ; *Chrysopogon montanum* was found to be highly self sterile and the seed setting in the other species ranged from 0 to 100 per cent. Different hybridisation techniques were worked out ; hot water treatment (about 50° C) for 4 to 9 minutes gave satisfactory emasculation. None of the interspecific hybridisations attempted have so far proved successful.

CYTOLOGY AND CYTOGENETICS

14. Crop improvement through colchicine-induced autopolyploidy :

The study of the induced autopolyploids of some oleiferous *Brassicaceae*, sesame and linseed was continued with special reference to the problem of seed setting in them. In sesame, the trends of the past few years indicate that seed setting, which was already very poor in these autotetraploids, became the poorer presumably as a result of homozygosis. In *toria* (*Brassica campestris* var. *toria*) the work of improvement of seed fertility of autotetraploid populations, through the application of the mass pedigree technique of selection, was continued ; the *elite* populations—Isolate A, Isolate B and Isolate C, representing pedigree mass selection carried over

three, two and one year respectively, were studied. It was observed that in Isolate A, the per cent frequency of high fertile plants had greatly increased during the recent years. The yield trial, conducted at Delhi with a superior autotetraploid population of *toria* and a corresponding diploid population was vitiated owing to damage caused by heavy winter rains; in a similar trial laid out at Pusa, the seed yield of tetraploids did not significantly differ from that of the diploid. The trials will be repeated. Comparative embryological investigations on diploid and autotetraploid *toria* revealed that non-fertilisation of the ovules, which appeared to be otherwise normal, was the principal cause of low seed-setting in the autotetraploids. Autotetraploid populations obtained from six other types of *toria* were under study; it was observed that these types showed a differential response at the tetraploid level, those obtained from T. 4 being more fertile than the others.

In linseed, selection for fertility in autotetraploid populations of N. P. (R.R.) 5 and N.P. (R.R.) 63 resulted in further rise of the percentage frequency of high-fertile plants; as compared to the corresponding diploids, seed setting in these tetraploids is yet rather low. An embryological investigation confirmed last year's findings that non-fertilisation of a large proportion of ovules in the tetraploids constituted the principal cause of low seed setting in them; slow or abnormal development of pollen tubes in the stylar tissue did not appear to lead to this inadequate fertilisation.

15. Interspecific and intergeneric hybrids of *Triticum* :

The F_4 generation of *T. vulgare*, $2n=42 \times T. pyramidale$, $2n=28$, was under study. A number of hexaploid and tetraploid segregates possessing ear characters of the opposite group were isolated. Three more nullisomics were also isolated, besides the one obtained last year.

Study of meiosis in F_1 hybrids of *T. vavilovi* with *T. vulgare* (N.P. 114) and *T. sphaerococcum* has previously shown the existence of segmental interchange heterozygosity in respect of chromosome structure. Study of meiosis in F_2 progenies of these hybrids indicated that this kind of structural hybridity was not related to the inheritance of the "branched" nature of the ear which is a characteristic feature of *T. vavilovi*.

Sterile F_1 hybrids obtained by crossing three varieties of *T. vulgare*, viz., N. P. 710, Pb. C. 591 and Pb. C. 228 with suitable strains of rye (*Secale cereale*) were treated with aqueous colchicine, using the "capping" method and seeds have been obtained from four of these cross combinations which would give *Triticale* strains next year.

16. Interspecific hybridisation involving the cultivated bhindi (*Abelmoschus esculentus*) :

Cytology of the sterile F_1 hybrid, *A. esculentus* ($n = 65$) $\times$ *A. tuberculatus* ($n = 29$) was studied. Pairing behaviour of the chromosomes at meiotic metaphase in this hybrid suggested that the cultivated *bhindi* is an amphiploid species comprising two genomes—one having 36 and the other 29 chromosomes, the latter complement being homologous with that of *A. tuberculatus*, the wild, disease resistant species. *A. tuberculatus* is so far the only species of *Abelmoschus* possessing $n=29$ chromosomes.

The fertile amphiploid (≈ 94), obtained by treating the above sterile hybrid with colchicine, was grown for the first time; it is proposed to be utilised for breeding for resistance to yellow vein mosaic in cultivated wheat.

17. Improvement of plant cytological technique :

Utilising the root tip squash technique, developed last year, the karyotypes of species of *Triticum* and *Aegilops* were studied. It appeared that the chromosome complements of the hexaploid species of *Triticum* bore greater resemblance to those of *T. durum* and *T. aestivum* than to those of the other tetraploid species. The hexaploid, *T. aestivum*, showed a feature unusual to *Triticum*; it possessed two pairs of identifiable nucleolar chromosomes having, in each, supernumerary constrictions separated from the secondary constrictions by a minute, intercalary, chromosome segment. The karyotypes of the 14-chromosome *T. aestivum*, *T. nigripectus* and *Ae. squarrosa* appeared to be clearly distinguishable, especially in respect of the SAT-chromosomes. In *T. aestivum* (Khaph), the presence of two distinct chromosomal biotypes, which also differed from each other morphologically, was noticeable. Another interesting observation was that every one of the tetraploid and hexaploid species of *Triticum* examined possessed two pairs of subterminally-constricted chromosomes; the pair of nucleolar chromosomes of *Ae. squarrosa*, which should have, in addition, been present in the hexaploid *T. aestivum*, was not identifiable, presumably owing to loss of the satellite heads during evolution.

With a view to confirming the above observations by study of mitotic chromosomes in pollen grains, an improved technique was developed and standardised; excellent preparations were obtained by the use of this technique.

PLANT PHYSIOLOGY

18. Study of drought resistance in wheat :

A replicated field trial was laid out under normal conditions with ten varieties of wheat, namely, N. P. 710, N. P. 165, N. P. 52, P.B. C. 228, Bajra, Afghanistan, Kende, Kathia, N. P. 798 and Ridley. From the periodical soil-moisture determinations up to the depth of three feet and the corresponding data on moisture equivalent it appeared that the crop was exposed to a substantial soil moisture stress. Although germination was satisfactory, the stand suffered considerably due to an acute white-ant attack. Therefore, yields could only be compared roughly on the basis of plant number. It was found that Punjab C. 228 was superior in yield only to Kende, Ridley, N. P. 798, N. P. 52, N. P. 165 and Kathia. Kathia was severely affected by rust.

A pot culture experiment was undertaken with the same three varieties as were used last year. During the last season selections of individual plants were made from "drought treatments" on the basis of ear and grain number and the grains from these were grouped as "high" and "low" class. These, as well as the grain from unselected plants, were sown separately during the season under report and the plants were raised under normal water supply, continuous intermittent drought and under intermittent drought from February onwards. The yields from the high and low classes did not differ in the case of N.P. 710; in the case of N.P. 798 the yield from

the high class was superior to that of the low class under normal water supply and continuous intermittent drought, while in the case of count Grain / Nphed 6 the yield from the high class was superior to that under normal water supply and under February drought. The associated class was found under normal water supply only and the interaction between variety and class was not significant. It would appear that there was some scope for selection for drought resistance in the case of the strains N.P. 119 and the cross Grain / Nphed 6. As in the previous season, the variety N.P. 119, out-yielded N.P. 118 and Grain / Nphed 6, particularly under drought treatment. Its superiority being due to higher grain number as well as tiller production. Observations on longevity of leaves and on pinching of stem and ear were also taken with a view to seeing if any difference in these could account for the superior yield of N.P. 119. The data collected in this connection have yet to be statistically analysed.

Crosses G. 226 / N.P. 50 F₁ / N.P. 504 and G. 504 / N.P. 50 F₁ / N.P. 504 were also raised under pot culture under normal water supply, continuous intermittent drought, and intermittent drought from February onwards. Selections of single plants were made from drought treatments on the basis of spikelet numbers, leaf size, earliness of mother shoots.

19. Physiological analysis of factors concerned with yield :

A pot experiment involving three varieties of wheat namely N.P. 119, Punjab G. 226 and Kanto, three sowing dates 14-10-53, 15-11-53 and 26-12-53 and two levels of nitrogen supply (adequate and deficient) was repeated with a view to ascertaining how far the differences in their ear characters were modified by environmental changes and how far these affected yield. It was found that as in the previous season, differences in spikelet number and 100 grain weight persisted rather more consistently than those in ear and grain number. Detailed observations on longevity of leaves and on pinching of stem and ear were also taken but the conclusions must await statistical analysis of the data.

20. Study of the influence of light and temperature on growth and development :

In a field experiment involving three sowing dates 10th October, 10th November and 12th December 1953 and three varieties of wheat namely Punjab G. 504, Balakrishnan 14 and N.P. 145 observations were recorded on the rate of increase in the weight of grain between anthesis and maturity with a view to finding causes for the differential performance of the varieties under different sowing dates. The results clearly show that the rate of increase in dry weight of grain per day was highest in G. 504 and least in Balakrishnan 14. The rate increased with delayed sowing in all the 3 varieties. But the period of growth is decreased with delayed sowing. The evidence here G. 504 gave higher yield than other varieties under late sowing. This confirms the previous years' findings.

21. Plant hormones :

In a pot culture experiment involving spraying with two hormones indole acetic acid and alpha-naphthalene acetic acid in three concentrations 20, 50 and 100 PPM, two levels of nitrogen and water supply respectively and two wheat varieties namely,

N.P. 710 and Punjab C. 225, it was found that nitrogen increased the yield of both the varieties whereas the hormonal spray increased the yield of N.P. 710 only. The interaction of nitrogen with water and micronutrient boron, zinc and molybdenum spray was significant. The characters most favourably influenced by the treatments were ear number and 100-grain weight.

In a replicated field trial, involving two varieties of wheat, N.P. 710 and Punjab C. 225, two levels of nitrogen (0 and 20 lbs. N per acre 30 days after sowing) and two levels of hormonal spray (0 and 10 PPM abscisic-acid-benzene emulsion, 4 months after sowing), it was found that in N.P. 710 the grain yield was raised by 2.5 mds. per acre by nitrogen and by 1.7 mds. acre by hormonal spray. The combined effect of two factors was not superior to that of the single factors. The yield of Punjab C. 225 was not influenced by either factor.

The effect of spraying 2.4-D and abscisic-acid-benzene emulsion on the plant and individual flower clusters of three tomato varieties, Desi Jackson, Sioux and Hybrid 5, grown under field conditions was studied. 2.4-D when sprayed on the flower clusters, increased the fruit yield by 15%, by increasing the fruit number. A slight increase in yield was also obtained in fruit size from 2.4-D sprayed on the plant. 2.4-D spray on flower clusters also helped to set fruit sooner in all the three varieties.

The effect of pre-sowing seed treatment with 2.4-D on the yield of two wheat varieties, N.P. 62 and N.P. 710, was studied in a replicated field trial. Seeds were soaked in water, 100-1000 and 10,000 PPM 2.4-D solutions for 14 hours. The treatments did not show significant increase in yield.

22. Lodging in wheat :

A replicated field trial was laid down with a view to determining the proper dose of nitrogen and its time of application to minimise lodging. The treatments were three varieties, namely N.P. 62, N.P. 710 and N.P. 100, three levels of nitrogen, namely 0, 10 and 20 lbs. per acre, four times of application, namely 0, 10, 20 and 30 days after sowing; another treatment involved application of the above mentioned doses of nitrogen at 0 and 10 lbs. less on the corresponding days after sowing. On the whole lodging appeared to diminish with delay in the application of nitrogen and the increase in yield was in no way adversely influenced by delaying the application of nitrogen until 30 days after sowing. This observation confirms that of the previous season.

23. Physiological studies in relation to the die-back disease of citrus :

The staff under this scheme could not be provided in full. The work done therefore mainly related to standardisation of techniques for the estimation of major and minor elements in plant, soil and nutrient solution. To this end, the evaluation of the most satisfactory and volumetric methods was under way. In the method for the estimation of malachowicz in soil, silica was found to interfere; methods of removing it were being worked out.

PLANT INTRODUCTION AND SYSTEMATIC BOTANY

24. Plant Introduction :

The work is being done since 1946 under a nucleus organisation manned by the Indian Council of Agricultural Research.

Nine hundred and four samples of seeds of various crops and other plants were imported from various foreign countries and 714 samples of seeds of crop varieties and 164 samples of wild growing plants were collected from within the country. The collections, both indigenous and exotic, now total 5,340. Eight hundred and fifty four seed samples of miscellaneous plants were supplied on request to various ponds.

The collections were grown during the *Kharrif* and *rabi* seasons for examination and study. At the request of the Kasumi Government, over 500 samples of seeds of various vegetables were grown for testing their performance.

A number of items from among the relatively older introductions are becoming popular. The Chinese sweet potato variety, "P. A. 17", is gaining popularity in Kasganj area of Etah district in Uttar Pradesh. In the States of Madhya Pradesh and Hyderabad, the American tomato variety, "Roxie", is receiving considerable favour from commercial growers as well as kitchen gardeners. Greeny bell peppers were paid to the vegetable growers variety, "Philippine Early", by Keshu Prasad Madho Kripal of Hapur (U.P.) who grew it on his land along with the local variety of that area. The early garden pea variety "Early Redgar" from America is also in demand.

The following are among the other promising items. In wheat, the varieties Tremex Molle, Tremex Rajo, Rahore, Bellala 115, Kyrie No. 144 and Tremex - received from the F.A.O. appeared to be resistant to all the three kinds of wheat. An orange fleshed selection of sweet potato, made from hybrid seed received from America, yielded 90 mds. of tuber per acre as compared to 148 mds. given by P. A. 17; the yields were rather low this year owing to insect attack. Orange fleshed varieties of sweet potato are rare in our native country and, although the yield of the selection was low as compared to that of P. A. 17, it still appears to be a profitable variety to grow in view of its superior quality and better performance than the local varieties. Some varieties, and one hybrid (H. 6535-6), of maize received from the U.S.A. were observed to develop their tassel quicker than the local varieties and were found to be high yielding; thus "Byar Green" and the hybrid H. 6535-6, gave 784 and 748 mds. per acre as against 562 mds. given by "Local Red". Some of these varieties, being yellowish coloured, do not keep as well as do the red coloured varieties and are therefore useful for marketing only as green maize early in the season. Two varieties of water melon, "Local Yamato II" from Japan and "New Hampshire Midget" from America, produced good crops of superior quality fruit.

Sorghum alatum, obtained from the U.S.A. appears to possess potentialities as a drought resistant fodder plant. Kozko 23, a newly evolved strain from America, was found to be quicker growing than the common kuzko. Three strains of oats from Europe and three from Australia gave good performance as regards vegetative growth and seed production and seem to be promising as sources of supply of green fodder late in the season.

25. Systematic Botany :

Three hundred and eight specimens were added to the Herbarium, the same now total 5,380. At the request of teaching and research institutions a number of plant specimens were supplied and several others taxonomically identified.

Survey and study of crop weeds at the Institute were taken up during the year according to the quadrat system and monthly observations recorded on the frequency of occurrence of different weeds: *Polypogon monspeliensis* appeared to be the most frequent among the *rabi* weeds. *Kochia indica* (Chenopodiaceae), a hardy, wild shrub growing plentifully around Delhi, appeared to be promising as a desert plant. The weed sets seed in November and the naturally disseminated seeds germinate in December, the seedlings thrive well on the winter rains and grow luxuriantly during April to June, the hottest months of the year. November-December, and not June-July as is commonly believed, thus seems to be the proper time for sowing seeds of this species. Seeds of this plant, when stored in cloth bags, lose their viability very soon; kept in glass-stoppered bottles, they remain viable almost throughout the year.

A small-scale botanical garden, for teaching purposes was planned; the work of laying out and planting was under way.

26. HORTICULTURE

Work on this Section commenced in April, 1954. The object of the section is to undertake research work for the improvement of fruit and vegetable plants and to impart postgraduate training in horticulture.

The 11-acre garden, previously planted with, mainly, varieties of mango and loquat by the Central College of Agriculture, was taken over and further work on the extension of the garden area to about 30 acres was being done. For realising some income from the orchard during the pre-bearing stage, a part of the area is being intercropped with vegetable crops.

27. BOTANICAL SUBSTATION, PUSA

This substation in Bihar is an important auxiliary station of the Division. The main items of work undertaken include (i) maintenance of crop collections, both indigenous and exotic, and trials of suitable among them for performance under north Bihar conditions, (ii) breeding and selection work on crops like wheat, linseed, pigeon pea, maize, etc., to obtain strains suitable for the north-eastern tract of the country and (iii) multiplication of foundation seed stocks of N.P. varieties of crop plants for distribution to growers in that region. The substation forms an important centre for breeding disease resistant wheats under the Co-ordinated Wheat Rust Control Scheme. The other Divisions of the Institute also conduct their experiments under the soil and climatic conditions obtaining in that region.

With a view to choosing a high yielding wheat variety for this region, a large-scale yield trial of 13 N.P. and other wheats was conducted. The newer varieties belonging to the "700-series", viz., N.P. 799 and N.P. 798, which are also highly rust resistant, significantly outyielded the others: their calculated acre yields were 17.89 mds. and 15.98 mds. respectively, as compared to 11.10 mds. given by N. P. 52, 10.52 mds. by B.R. 319 (one of the improved strains of the Bihar Department of Agriculture) and 7.74 mds. by the local variety. In *arhar*, the newly-evolved wilt-resistant strain, N.P. C15 Pusa, has been found to be the most suitable for this area. Small-scale replicated and randomised yield trial experiments were conducted with a number of varieties of pungent and non-pungent chillies; in pungent chillies,

the strains—N.P. Hyb. 5-1-5, N.P. Hyb. 7-1-4 and N.P. 41 gave, respectively, 44.6, 39.6 and 34.4 per cent increased yields over the local and in non pungent chillies. Bell Pepper and R. 419 gave, respectively, 33.3 and 17.5 per cent higher yields than the local, thus confirming previous year's results. Hybrid No. 45 of potato proved to be the best and gave about 51 per cent more yield than Phulwa. The Chinese variety of sweet potato, F.A. 17, gave, as compared to the best local "Alpan", 23.5 per cent increased yield during the September-January crop season and 51.8 per cent increased yield in the January-June season; this variety gave superior yield over the local in a cultivator's field also.

The crops were also grown in connection with Permanent Manurial and Rotational Experiments and the New Manurial Experiment, being jointly conducted by the Divisions of Agronomy and Chemistry. Also for the Agronomy Division, two experiments were conducted for determining the suitability, as fertilisers, of dicalcium phosphate and semi-acidulated rock phosphate (Kotka phosphate). The data on these experiments would be reported upon by the Divisions concerned.

PROGRAMME OF WORK FOR THE YEAR 1954-55

1. Improvement of Indian wheat with special reference to evolving varieties resistant to rusts, smuts, bunts and to drought and lodging.
2. Study of suitability of N.P. wheats and other breeding material to irrigated and *bacani* conditions and to special conditions like rich soils, late sowings, etc.
3. Breeding for disease resistance and other qualities in crops other than wheat—e.g., breeding for rust resistance in linseed, wilt resistance in pigeon pea, etc.
4. Trials of recently evolved improved N.P. strains of crop plants, e.g., wheat, linseed, pigeon pea, tomato, etc., in the different states of India.
5. Investigations on the utilisation of hybrid vigour in maize, tomato, onion, *bhindi* and radish. Trials in the states of foreign hybrid maize.
6. Breeding of early-ripening and high-yielding varieties of *bajra* and fodder and grain varieties of *jowar*.
7. Breeding of some pasture grasses and legumes for northern India.
8. Study of wild relatives of crop plants and their utilisation in crop breeding, e.g., in wheat, *bhindi*, etc.
9. Induction and study of polyploidy in crops, like *Brassica*, linseed, etc., as a method of crop improvement and trial of some of these polyploids.
10. Cytogenetical studies of *Triticum* species and of interspecific and intergeneric hybrids involving *Triticum*.
11. Improvement and application of cytological technique.
12. Physiological studies on drought resistance in wheat.
13. Physiological analysis of factors concerned with yield in wheat.
14. Influence of light and temperature on growth and development in wheat.
15. Physiological aspects of plant nutrition in wheat: studies on the relation between varietal differences in the uptake of nutrients.
16. Lodging in wheat—physiological appraisal of factors concerned with lodging.

17. Plant hormones : investigations on the role of different hormones on growth and development in wheat and on the usefulness of hormones as weedicides.
18. Plant physiological studies in relation to the die-back disease of citrus.
19. Systematic classification of varieties of hill wheats.
20. Study of weeds and their succession in crop fields.
21. Plant introduction and collection of indigenous plants of economic value—their maintenance, study and trials in Delhi and other States.
22. Horticulture, extension of the garden area for purposes of research work on fruits and vegetable plants and supply of nursery plants.
23. Intensification of multiplication and distribution of seed of improved N.P. varieties of field and vegetable crops.

REPORT OF THE DIVISION OF SOIL SCIENCE AND AGRICULTURAL CHEMISTRY FOR THE YEAR 1953-54.

(DR. S. P. RAYCHAUDHURI)

The main objective of this Division is to study the soils of India in relation to their crop producing power and to carry out investigations on soil conditions and manurial practices that would prove useful in increasing the yield and the quality of crops. The activities are divided under different sections, viz. Soil Chemistry (including Agricultural Chemistry, Soil Fertility and Micronutrients), Soil Physics, Soil Survey, Physical Chemistry, Organic Chemistry, Soil Microbiology, Biochemistry and Physics.

SOIL CHEMISTRY

(a) Agricultural Chemistry :

1. *Fertilizer value of dicalcium phosphate.*—In field experiments on non-calcareous Delhi soil, dicalcium phosphate, superphosphate and bone meal applied alone gave no response on paddy but in combination with ammonium sulphate, increased grain yields of 254 lb., 406 lb. and 206 lb. per acre respectively were obtained. The results indicated higher response with super than the other two fertilizers.

Berseem responded to residual phosphatic fertilizers alone in the above experiment giving increased yield of 16,970 lb. with dicalcium phosphate, 18,600 lb. with super and 6,800 lb. with bone meal. F.Y.M. alone gave a residual response of 14,800 lb. The efficiency of response with dicalcium phosphate and super was increased when in combination with F.Y.M.

On the calcareous soil at Pusa, dicalcium phosphate and super alone increased the yields of wheat grain by 393 lb. and 439 lb. respectively. The efficiency of the phosphatic fertilizers was increased when in combination with F.Y.M. Bone meal alone or in combination with F.Y.M. gave no response on the calcareous soil.

The experiment indicated that, as a phosphatic fertilizer, dicalcium phosphate is as effective on wheat as super in calcareous soil.

2. *Soaking of roots of paddy seedlings in nutrient solutions.*—Small scale field experiments were conducted to confirm last year's observations from pot experiments on the effects of dipping paddy roots in fertilizer solution—soil pastes before transplanting. The average yields obtained indicated beneficial effects of treatment with 5 per cent ammonium sulphate and ammonium phosphate pastes. The experiment is being repeated on a field scale.

3. *Fertilizer value of ammonium chloride and ammonium sulphate-nitrate.*—In field experiments carried out in collaboration with Agronomy Division, increased yield of paddy grain with 20 lb. N per acre was 495 lb. with ammonium chloride and 322 lb. with ammonium sulphate-nitrate as compared to 547 lb. with ammonium sulphate. At the dose applied, the nitrogen in different forms was more or less equally utilized for increased growth of the crop without affecting its chemical composition.

Wheat gave increased yields of 647 lb. grain with ammonium chloride and 461 lb. with ammonium sulphate-nitrate as compared to 456 lb. with ammonium sulphate. Increasing the dose of fertilizers to 40 lb. N per acre did not significantly increase yields further.

The experiment indicated that ammonium chloride and ammonium sulphate-nitrate applied to paddy and wheat crops gave significant increases in yield comparable to ammonium sulphate.

4. *Effect of Homeopathic drugs on crop growth.*—At the instance of the Ministry of Food and Agriculture, experiments were conducted to test the effect of a homeopathic compound "Varkshotone" on the growth and yield of cowpea and wheat crops. The trials showed no beneficial effect on the crops.

5. *Manurial value of NP fertilizer.*—At the instance of the National Chemical Laboratory, trials were undertaken to test the fertilizer value of a mixed NP fertilizer manufactured by them on a pilot scale. The product contained 6.6 per cent ammonical nitrogen, 8.4 per cent water soluble P_2O_5 and 4.8 per cent citrate soluble P_2O_5 .

In pot experiments, the NP fertilizer applied at 50 lb. N and 107 lb. P_2O_5 per acre gave significant increases in yields of Marua (*Eleusine coracana*) and wheat crops over application of ammonium sulphate at the same rate of nitrogen. The response obtained with ammonium sulphate and superphosphate in combination at the same levels of nitrogen and phosphoric acid was, however, superior to that with the NP fertilizer.

(b) Soil Chemistry :

1. *Rapid estimation of available nitrogen in soils.*—A rapid chemical method of determining available nitrogen in soil by the use of alkaline permanganate solution has been developed. There was no correlation between total soil nitrogen and mineralized N determined after incubation of soil. Values obtained from preliminary digestion of soil with 0.32 per cent $KMnO_4$ made alkaline with 2.5 per cent NaOH and subsequent distillation were found to be highly correlated to mineralizable nitrogen determined from incubation of soil under optimum conditions. The method gave reproducible results.

2. *Rapid chemical tests for plant nutrients in relation to crop response on laterite soils.*—Samples of laterite soils collected from Agronomic Experimental fields in Bihar gave available nitrogen values, determined by alkaline permanganate method, which were found to be inversely correlated with the extent of crop response to nitrogenous fertilizers. Similar studies on available phosphorus are in progress.

3. *Comparative study of the methods for determination of nitrate-nitrogen in soils.*—Brucine and diphenylamine spot tests were found to give rapid and sufficiently accurate estimates of nitrate nitrogen in different types of soils.

The Brucine photometric procedure was more rapid than the conventional phenol di-sulphonic acid method and gave accurate results even in the presence of chlorides.

The operation of evaporation of the aliquot in the phenol di-sulphonic acid method could be eliminated by dehydrating the water extract with fuming sulphuric acid instead and then developing the colour as usual.

4. *Studies on the relative efficiency of different phosphatic fertilizers and methods of increasing their availability.*—Pot experiments on wheat crop showed that at 60 lb. and 120 lb. P_2O_5 per acre applications in the forms of Triple super phosphate, dicalcium phosphate, nitrophosphate, ammonium phosphate and bone meal over a basal dose of 40 lb. N, maximum response of 36.7 per cent and 67.5 per cent at the two levels of P_2O_5 was obtained from Triple super.

(c) Soil Fertility :

1. *Building up of soil fertility by phosphatic fertilization of legumes.*—Results of 8 years of Lysimeter experiments concluded during the year show that (i) response to phosphatic fertilization is more marked on berseem than on cowpea, the yield of berseem increasing by as much as 200 to 230 per cent over no manure as compared to 50 to 70 per cent of cowpea ; (ii) application of ammonium sulphate in combination with superphosphate maintained yields at higher level in the cereal rotation maruwa-wheat. The level of yields of wheat was equal to that obtained in the rotation berseem (P fertilized)—wheat ; (iii) chemical analysis of wheat in the two systems of rotation showed no differences.

2. *Effect of compost application on the humus level of soil :* (in collaboration with Agronomy Division).—Application of compost at 40 to 120 lb. N per acre to maize in the rotation maize-wheat showed increases of 20 to 29 per cent in organic carbon content of the soil after one year, as compared to 10 per cent increase with ammonium sulphate at 80 lb. N per acre. There was, however, no corresponding increase observed in the nitrogen content and the over-all C/N ratio consequently showed a rise from 8.56 to 10.0.

3. *Effect of application of straw on the humus level of soil :* (in collaboration with Agronomy Division).—Application of 20 to 30 md. of wheat straw per acre alone and in combination with ammonium sulphate to maize in the rotation maize-wheat did not show any appreciable increase in organic carbon or nitrogen contents of soil at the end of one year.

4. *Utilisation of phosphatic materials through composting.*—Pot experiments on marua (*Eleusine coracana*) and berseem crops showed that the efficiency of response to superphosphate can be significantly increased if the fertilizer is composted along with cattle wastes.

Insoluble rock phosphate proved ineffective when applied as such in combination with prepared compost. The availability was significantly increased when the material was composted with cattle wastes.

5. *Fuel Gas from cattle dung.*—The working of the experimental cow-dung gas plant showed that over a period of 10 months, average production of gas was 0.95c.ft. per pound of dung added. The composition of the gas was 55 per cent methane, 10 per cent hydrogen and 35 per cent carbon dioxide. The gas gave a non-luminous flame and could be used for laboratory or household heating and lighting purposes and for running a 3.5 H.P. engine. The digested slurry contained 1.9 to 2.4 per cent nitrogen, of which about 10 per cent was in the form of ammonia and was liable to loss on drying, due to the alkaline reaction of the slurry.

In pot experiments, the residual manure from the gas plant gave higher yields than ordinary farm yard manure, but was inferior to ammonium sulphate on equal nitrogen basis.

Laboratory trials showed that other organic materials like green leguminous plants, ground nut shells and molasses could also be utilised for gas production by anaerobic fermentation.

(J) Micro-nutrients :

1. *Microelement status of Indian soils.*—Examination of an 8 ft. deep profile of undisturbed soil taken from the Institute area in 1958 showed contents of 389 to 567 p.p.m. of Mn, 10 to 22 p.p.m. of Cu, 9 to 21 p.p.m. of Zn and 4 to 6 p.p.m. of Co. Except Mn, which showed higher values in the top layers, the distribution of the other micronutrient elements along the profile showed no particular trend.

2. *Micro-elements in grasses and forage crops.*—In pot experiments, heavy black cotton soil containing 1 p.p.m. of molybdenum gave additional yield of berseem with application of 2 lb. per acre of molybdenum oxide along with nitrogen and phosphate. The response to application of molybdenum on Delhi soil was not appreciable.

SOIL PHYSICS

1. *Effect of application of lime and organic manures on formation of water stable aggregates in soil.*—Maximum effect on formation of water stable aggregates on treatment of soil with 2 per cent lime, F.Y.M. and green manure (guar) was observed 2 weeks after application, green manure showing the highest increase from an average of 33.4 per cent to 143. The effect declined on further storing for 4 and 6 weeks. Highest increase in yield of oats (50 per cent) was obtained with green manure decomposed for 6 weeks before sowing, followed by F.Y.M. (25 per cent) and lime (10 per cent). The effect of the treatments was more marked on loamy soil than on sandy loam.

2. *Effect of soil conditioners on physical properties of soil and plant growth.*—In laboratory experiments, addition of 0.1 per cent of soil conditioners increased the proportion of water-stable aggregates larger than 0.5 mm. from 2.2 per cent to 28.5 per cent. The commercial product 'Krilium' proved better than 'Aerofil' and 'Polyack'. Application of krilium improved germination of wheat from 14.3 per cent to 86.0 per cent in heavy soil containing 45 per cent clay. The soil conditioner was not effective in improving the physical condition of alkaline soil.

3. *Soil moisture tensiometer.*—The soil moisture tensiometer with mercury manometer fabricated in the laboratory enabled estimation of soil moistures upto field capacity and gave good indications for the need of irrigation to crops.

SOIL SURVEY

1. *Genesis and classification of Indian soils.*—Mineralogical examination of the alluvial soils of Delhi and red soils derived from quartzite rocks showed that the provenance of the two soils are possibly different. Fresh quartzites of Delhi ridge contained considerable quantities of dark green hornblende and light pink garnet and minor quantities of brown tourmaline, magnetite, sillimanite and mica in the heavy mineral suite. The genesis of red soils from quartzites is under investigation.

The black soils of Kotah State show typical morphological and chemical characteristics of 'regur'. The red soils of neighbouring Bundi State are loamy to clay loam and possess high cation exchange capacities. The derived ratios of clay show an intermediate nature. Minerological analyses of the black and red soils show some similarities. The black soils are derived chiefly from trap rocks but transported and deposited in proximity to soils from metamorphic rocks. The red soils are sedentary and derived from metamorphic shales, and slates, etc.

2. *Reclamation of alkali soils.*—Alkalinity developed in plots of the Botany Division of the Indian Agricultural Research Institute was corrected by the application of gypsum and flooding. The method of reclamation is being extended to other plots.

3. *Soil and land utilization survey of the Little Rann of Kutch.*—Soil and land utilization survey of the Little Rann of Kutch indicated that, of the total area of 1,400 sq. miles of the salty tract, about 3 lac acres may be suitable for reclamation.

PHYSICAL CHEMISTRY

1. *Investigations on the formation of saline and alkaline soils.*—The limit of sodium saturation of the exchange complex for formation of alkali soils was found to depend on the mineral constitution of clay, the concentration of soluble salts and the nature of the dominant salt.

Effective flocculation of sodiumized soil with electrolytes was found to vary with the type of clay minerals and their combination in the clay complexes.

Examination of saline patches in the Farm at Pusa showed that there were underground mounds of water which, during its movement through subsoil, dissolved and collected soluble salts. When the accumulated salinity became sufficient, the greater permeability of soil favoured upward movement of the salts forming saline patches on the surface.

2. *Studies on the formation of useful clay-mineral and clay-humus complexes in soil.*—From a study of synthetic precipitates, it was found that, in soil formation processes which give rise to clay mineral complexes possessing cation exchange properties, the alumino-silicates formed are chemical compounds of definite composition. In the range of $\text{SiO}_2/\text{R}_2\text{O}_3$ higher than 7.5 to 7.9 of the alumino-silicates, the structure of the compound is in units of 24 tetrahedra with 4 Si substituted by other cations. With $\text{SiO}_2/\text{R}_2\text{O}_3$ below 7.5, the structure separates out into Octahedra and tetrahedra layers while between 7.9 to 10, both the types of structures are present.

Black soil from Padegaon was found to contain a higher proportion of electrolyte sensitive and fertility indicating clay humus complexes than cinchona soil from West Bengal. Manuring with F. Y.M. produced this fraction in the soil more than application of groundnut cake or green manuring.

ORGANIC CHEMISTRY

1. *Nicotine sulphate from Tobacco waste.*—For the denicotinisation of kerosene oil extract of tobacco waste with sulphuric acid in the specially designed extractor,

the optimum concentration of the acid was found to be 30 per cent. Nicotine sulphate containing over 40 per cent nicotine could be prepared by the method employed.

2. *Organic thiocyanates*.—Longifolyl thiocyanate synthesized in these laboratories gave 78 per cent control against mustard aphids on a semifield scale and in the concentrations employed, showed no phyto-toxicity. The compound has potentialities of commercial production from indigenous raw materials.

Longifolyl alcohol, an intermediate formed in the preparation of longifolyl thiocyno acetate, has shown promise as a fixative in perfumery according to reports received from India and abroad.

Longifolyl alcohol has been resolved into two secondary alcohols. An instance of phthalation of secondary alcohols in benzene solution has been established for the first time in the case of the longifolyl alcohols.

Sesquiterpene recovered from the reaction of longifolyl alcohol with acetic-sulphuric acids was unaffected on keeping or exposure to air. The recovered hydrocarbon could therefore be used as a cheap and effective solvent for the production of protective coatings.

3. *Chlorinated terpenes as insecticides*.—Chlorinated delta-3-carene containing 50 per cent chlorine showed toxicity against *Trialeurodes castaneae* which was comparable to that obtained with an imported product 'Toxaphane'—a chlorinated comphene of 68 per cent chlorine content. Other terpenes of the Indian oil of turpentine of the same chlorine content showed lesser degree of toxicity. The particular effect of delta-3-carene molecule is being investigated.

4. *Synergists for insecticides*.—Methods for the recovery of about 9 per cent alcohol from the oil layer in the preparation of synergists are being investigated. This would enable the cost of the process to be reduced substantially.

Possibilities of utilizing isolates from seeds of *Myrsinaceae* family growing wild in Western Ghats for use as synergists for pyrethrum are being examined.

5. *Insecticidal formulations*.—Surface active properties of polyglycerols, having possibilities of production from indigenous raw materials, were found to be somewhat inferior to polyethylene glycols for emulsification.

Some formulations of DDT containing organic thiocyanates and synergists synthesized in the laboratory were prepared with a view to impart knock-down and appicidal properties. The formulations are under test.

6. *Determination of quality of oil in small samples of oil seeds*.—A new inexpensive method has been developed for the photocolometric estimation of tocopherols using ferric sulphate-potassium ferriocyanide reagents. The method enables estimation of tocopherol content of the order of 15 to 20 microns.

7. *Detection of adulteration of ghee*.—Further studies on the use of ethyl tyrosinate as an indicator substance showed that it was thermally stable upto 230°C and did not undergo any decomposition during storage for 8 months. The indicator could not be removed from the hydrogenated fat by adsorbents.

SOIL MICROBIOLOGY

1. *Utilization of indigenous phosphates through legumes.*—Effect of super phosphate, bone meal, trichy phosphate and Singhbhum phosphate on the yield of guar and its subsequent effect on wheat was investigated. The following tables shows the yield of guar and the succeeding green manured wheat.

Yield in gm. per pot. (average of 6)	Control. gm.	Superphos. gm.	Bone meal. gm.	Trichi phos. gm.	Singhbhum phos. gm.
Guar	36.3	41.0	36.0	35.1	35.9
Wheat	19.6	27.0	18.5	16.2	18.7

The experiment showed that bone meal, Trichy and Singhbhum rock phosphates could not be effectively utilized for increasing the growth of guar green manure.

2. *Modified method of utilizing sannhemp for manurial purposes.*—The crop of sannhemp is allowed to mature and harvested for extraction of fibre. The seed produced is returned to the soil, allowed to germinate and then buried as manure. Succeeding wheat and onion crops were thus found to give additional 7 per cent and 5 per cent yields over the usual method of green manuring sannhemp. From the modified method, an extra yield of 1,448 lb. of fibre per acre was obtained.

3. *Acceleration of decomposition of green manure.*—Sannhemp treated with a 5 per cent emulsion of cowdung with water at the time of green manuring indicated better decomposition and gave 8.4 per cent more yield of grain of the succeeding wheat crop than the untreated green manure.

4. *Mechanism of nitrogen fixation in Rahar.*—The roots of rahar crop do not exhibit the normal nodule formation found in other leguminous crops. Examination of the leaves of the crop showed the presence of *Azotobacter*. The organisms was rod shaped, motile and capable of fixing 4 mgm. of nitrogen in Ashby's mannite solution. Further studies are in progress.

5. *Use of activated Azotobacter soil culture.*—In pot experiments, the yields of Marua crop treated with 1 per cent berseem hay and F.Y.M. were improved by 158 per cent and 49 per cent respectively when 10 per cent of activated soil culture of *Azotobacter* was applied in addition. Wheat straw proved to be the best energy material for fixation of nitrogen by the soil culture of *Azotobacter* but the fixed nitrogen was not immediately available. The depressing effect of wheat straw alone on the yield of wheat was, however, minimized in the presence of *Azotobacter* soil culture. The results on the residual effect of the above treatments on succeeding wheat were not conclusive.

6. *Studies on wild leguminous plants.*—On the basis of characteristics of growth, nitrogen content and nitrification of green matter, four kharif wild leguminous plants were found suitable for use as green manure crops. In a field trial, *Mucuna*, as green manure gave 63 per cent increased yield of wheat over sannhemp.

An organism isolated from the stem of the water-legume *Aeschynomene aspera* appears to belong to the genus *Rhizobium* of the family *Rhizobiaceae* and functioning like the root nodule organisms in the common legumes. Cross inoculation tests with legumes of well known cross inoculation groups are in progress.

7. *Studies on sulphate reducing organisms.*—Presence of sulphate reducing organisms have been detected in 22 samples of tank silts from various sources. Production of hydrogen sulphide by the organisms was found to be stimulated by the addition of 2 per cent sodium chloride to the solution.

8. *Studies on the nitrogen-fixing flora in tank silts.*—Pure cultures of *Azotobacter* were isolated from 22 samples of tank silts. Fixation of nitrogen by the organisms varied from 2 to 7.4 mgm. per gram of mannite.

Nitrogen fixation by the algae from the above silts varied from 0.3 to 5 mgm.

9. *Production of fuel gas from organic waste materials.*—Production of fuel gas from cattle dung under anaerobic conditions was found to be stimulated by the addition of 1 per cent of phosphatic materials like Trichy phosphate, superphosphate, Singhbhum phosphate and bone meal. The volume of gas obtained from 150 lb. of dung increased from 3.0 c.ft. per day to 4.13 c.ft. with Trichy Phosphate.

5 per cent solution of molasses to which calcium carbonate, calcium phosphate and ammonium sulphate were added gave, on fermentation, about 4 c.ft. of combustible gas per pound of dry matter.

Mahua cake gave 1 c.ft. of gas per pound of the cake.

10. *Utilisation of Mahua cake as manure.*—Application of Mahua cake was found to have no toxic effect on the general microbiological population of the soil. Pot experiments with pea and wheat crops showed that the cake could be profitably utilized as manure in combination with ammonium nitrate and urea.

BIOCHEMISTRY

1. *Nutritive value of food crops as affected by manurial, cultural and management practices.*—Biological value of the proteins of two strains, each of gram, urid, mung, lentil, rahar and pea determined by the protein efficiency method on rats showed strain variations. Gram gave the highest biological value followed by urid and pea. One of the strains in each of the pulses appeared to be as good as urid or pea indicating that the quality of proteins can be improved by selective cultivation or hybridization. No correlation was observed between true or total protein and their biological value. Strain variations were also observed in the content of protein, non-protein nitrogen, iron, total and phytin phosphorus.

The utilisation of the pulse proteins was markedly improved when vitamin B₁₂ and methionine were both added to the diet.

2. *Thiamine content of Indian cereals.*—Pure strains of some of the varieties of Indian wheats and pulses showed thiamine contents of 4.1 to 6.5 µg/gram. Titration and turbidity methods gave comparable results.

3. *Chemical composition and nicotinic acid contents of wheat as influenced by locality.*—Nicotinic acid content in samples of C591 variety of wheat grown under different soil and climatic conditions varied from 41 to 63.9 µg. per gram. The

values were generally higher for alluvial soils as compared to black soils. The protein content showed higher trend in black soils than alluvial soils. Variation in P and Ca contents of NP 52, C 591 and K13 varieties of wheat grown in different localities have also been observed.

4. *Phytin and other forms of phosphorus of wheat as affected by manuring and crop rotation.*—P content of wheat grain varied from 0.216 to 0.387 per cent under different manurial treatments and rotations. Nitrogenous fertilizers and organic manures alone tended to decrease concentration of P. Phosphatic fertilizer alone or in combination with nitrogenous manures showed increases in P content of grain. Phytin P varied from 0.81 to 0.197 per cent.

5. *Quality of wheat as affected by micro-element fertilizers.*—The quality of wheat as influenced by fertilization with micro-elements like copper, zinc, manganese and magnesium is under study. Analysis of the crop from the different treatments is in progress.

6. *Effect of spraying of urea solution on the quality of wheat.*—Wheat plants at the flowering stage were sprayed with varying concentrations of solution of urea to study its effect on the quality of protein. The doses above 6 per cent of urea were found to be injurious. Work is in progress.

7. *Nature of proteins in food and feeding stuffs.*—Improvements in paper chromatographic technique and methods of hydrolysis of proteins for quantitative determination of amino-acids in plant materials were developed.

Different varieties of wheat, pulses, grasses and legumes are being examined for their essential amino-acid contents by the microbiological method. Indian pulses showed poor contents of cystine and tryptophane which were of the order of 0.052 to 0.245 per cent and 0.036 to 0.081 per cent respectively.

8. *Nitrogen metabolism in soil.*—The amino-acid make up of the typical black cotton and red soils was qualitatively the same. Amino-acids identified in both the soils were : aspartic acid, glutamic acid, serine, glycine, threonine, alanine, tryptophane, histidine, lysine, arginine, methionine, phenyl-alanine and leucine.

Studies on the nature of amino-acids excreted by leguminous crops showed presence of arginine in appreciable amounts in the soil under berseem crop fertilized with 120 lb. P_2O_5 per acre. The significance of this is being investigated.

9. *Carotene content of food and feeding stuffs.*—Carotene content of 6 different varieties of sweet potato was found to vary between 3.3 and 127.0 p.p.m. In 7 samples of grasses and legumes examined, carotene varied between 33.9 and 63.9 p.p.m.

10. *Biochemical studies on tomato.*—Vitamin C content of 30 different varieties of tomato varied between 17.9 and 70.5 mg. per 100 gm. The vitamin C content of tomatoes kept for ripening at room temperature for a week did not show any variation during the period of storage.

11. *Chemical composition and nutritive value of Indian wheats (I.C.A.R. Scheme).*—In 24 different varieties of wheat of the Botany Division, I.A.R.I. and Pusa Sub-station, protein content varied between 9.1 and 14.9 per cent, Calcium between 0.41 and 0.79 per cent, phosphorus between 0.21 and 0.39 per cent, phytin phosphorus between 0.14 and 0.29, and nicotinic acid between 44.2 and 62.4 micrograms per gram.

14 other varieties collected from different parts of India are being examined for their chemical composition.

PHYSICS

1. *Spectroscopic methods of analysis.*—The optimum conditions for maximum sensitivity of flame emission in the Lanthanum flame emission spectrograph were worked out with 15 lb. of compressed air pressure. Using acetylene pressure of 42 cm. of water, the accuracy of determination of the following elements, worked out as given below :—

Element	Error
K	3—4%
Na and Ca	10%
Fe	4—5%
Mg and Mn	7%

2. *Estimation of sodium.*—A modified distillation flask for the extraction of sodium from tomato fruits grown on tobacco-mosaic grafts and from other materials was designed. Using this, extracts containing 1 percent of the order of 100 per cent could be distilled and estimated using the absorption spectrographic technique.

Scheme of Research for Preparation of a Monograph on Agriculture in Ancient India "

During the third year of the I.C.A.R. Scheme on the Preparation of a Monograph on "Agriculture in Ancient India", further valuable information on the subject was collected from various public libraries as well as private manuscripts. The preparation of the monograph in 3 volumes is in progress.

Scheme for the Study of Physical Properties of Certain Chemical Fertilizers during Storage

Under the Scheme initiated by the I.C.A.R., observations on the Physical and Chemical changes during storage of Ammonium Sulphate, Urea, Ammonium Nitrate, Nitrophosphate, Ammonium Phosphate and Triple Superphosphate are in progress at Durgam. The data obtained so far show that nitrophosphate is highly hygroscopic and loses its physical condition. Ammonium nitrate is equally hygroscopic. These two fertilizers can only be stored in special moisture proof bags. Urea is hygroscopic but forms into hard lumps on drying. Ammonium sulphate may absorb small amounts of moisture but lumps badly on drying. Ammonium phosphate retains its condition and is unaffected by changes in humidity and temperature.

Scheme on Agronomic Trials and Soil Fertility and Fertilizer Use

Under the Technical Co-operation Agreement, agronomic trials with different nitrogenous and phosphatic fertilizers at 40 centres are in progress. Field trials on paddy at different centres indicate that differences in response due to type of nitrogen in the forms of ammonium sulphate, urea and ammonium nitrate are

generally small and there are soils which respond to phosphate in combination with nitrogen. Application of 40 lb. dose of nitrogen gives generally a substantial increase over 20 lb. N dose. Placement of phosphatic fertilizers indicated better response than broadcast application.

Soil Survey work is in progress in Coorg, Madhya Pradesh, Bombay and Delhi States. Characteristic soil profiles and associated soil samples in these areas have been collected for detailed examination.

PROGRAMME OF WORK FOR 1954-55

I. SOIL CHEMISTRY

(a) Agricultural Chemistry :

1. Fertilizer value of di-calcium phosphate and semi acidulated rock phosphate.
2. Effect of soaking seeds and paddy roots in nutrient solutions.
3. Fertilizer value of ammonium chloride and ammonium sulphate-nitrate.
4. Studies on the transformation, availability and crop response of some nitrogenous fertilizers.
5. Availability of bonemeal phosphate as affected by fineness.

(b) Soil Chemistry :

1. Development of rapid soil tests suitable for different soil types of India.
2. Standardisation of methods of soil analysis.
3. Studies on the nature of salinus and alkaline problems in different soil types of India.
4. Studies on the nature of red and laterite soils of India.
5. Comparative value of different phosphatic fertilizers and methods of increasing their availability.

(c) Soil Fertility :

1. Effect of compost application on the humus level of soil.
2. Effect of application of wheat straw and chemicals on the humus level of soil.
3. Pretreatment of superphosphate by composting and its effect on crop yields.
4. Pretreatment of rock phosphate by composting and its effect on crop yields.
5. Chemical composition of plant tissues as indicating fertilizer requirements.
6. Production of combustible gas and manure from dung and other organic materials.

(d) Micronutrient elements :

1. Micro-element status of Indian soils :
 - (a) Laboratory examination of soils,
 - (b) Pot culture experiments to correlate crop response with micronutrient element status.
2. Uptake of micro-elements by grasses and forage crops.

II. SOIL PHYSICS

1. Studies on soil aeration.
2. Studies on soil moisture.
3. Effect of soil conditioners on physical condition of soil and plant growth.

III. PHYSICAL CHEMISTRY

1. Investigations on the formation of saline and alkaline soils.
2. Investigations on the formation of useful clay minerals and clay-humus complexes in soils.
3. Studies on the anion exchange capacity of Indian soils.

IV. SOIL SURVEY

1. Indian soils—their genesis and classification—Black, Red, Laterite, Desert and Alluvial soils.
2. Study of saline and alkaline soils.
3. Study of soil minerals.
4. Collection of soil monoliths.
5. Soil mapping and cartography.
6. Soil conservation and land reclamation.
7. Schemes :
 - (i) T.C.M. Soil Survey.
 - (ii) Intensive Cultivation Scheme of Delhi villages.
 - (iii) Survey of Little Rann of Kutch.

V. ORGANIC CHEMISTRY

1. Biogenesis of fats.
2. Estimation of quality of oil in small samples of oil seeds.
3. Use of synthetic sesamol as indicator for detection of adulteration.
4. Prevention of rancidity of edible oils and fats.
5. Chemical composition, nutritional properties and nutritive value of oil seeds, oil and fat products.
6. Studies on synergists for insecticides.
7. Insecticidal formulations.

VI. SOIL MICROBIOLOGY

1. Cultivation of nitrogen-fixing organisms in the laboratory and in the soil through legumes.
2. Cultivation of *Acetobacter* and *Alcaligenes* under symbiosis.
3. Studies on fixation of nitrogen by *Rhizobium*.
4. Inoculation experiments with legumes.
5. Studies on the activation of *Acetobacter*.

6. Studies on wild leguminous plants.
7. Studies on the nitrogen fixing flora of tank silts
8. Production of fuel gas from agricultural wastes.
9. Studies on sulphate reducing organisms.
10. Utilization of mahua cake.

VII. BIOCHEMISTRY

1. Studies on soil metabolism :
 - (a) Paper chromatographic estimation of sugar and amino acids in soil.
 - (b) Soil enzymes.
2. Nutritive value of foods, feeds and fodders :
 - (a) Amino-acid composition,
 - (b) Biological value,
 - (c) Chemical composition and vitamin content.
3. Quality of wheat as affected by micro-elements/fertilizers
4. Quality of wheat protein as affected by urea spraying.
5. Chemical composition and nutritive value of Indian wheat

VIII. PHYSICS

1. Comparison of spectrographic, colorimetric and chemical methods of analysis of major and micro-elements.
2. Micro-elements in soils and plant materials.
3. Absorption spectrographic techniques :
 - (a) Movement of nicotine in tobacco-tomato grafts,
 - (b) Estimation of pyrethrin.

REPORT OF THE DIVISION OF ENTOMOLOGY FOR THE YEAR 1953-54.

(Dr. E. S. NARAYANAN)

The functions of this Division are to undertake research on fundamental and applied aspects of Entomology so as to devise easy and accessible means of insect control. In view of this it was necessary to take up investigations in Insect Systematics and to maintain a good collection of insects as well as cultures of parasites, viz., *Trichogramma*, *Bracon* and *Apanteles*. The comparative toxicity of fumigants and insecticidal dusts was also investigated. The main activities of the Division during the year under report comprised the maintenance of insect collections, teaching post-graduate and under graduate students and research projects in Parasitology, Systematics, Ecology and Toxicology.

I. GENERAL

(A) National Pusa Collection :

(i) Holotypes of 5 new species of *Evania* (Hymenoptera : Evaniidae) received from Dr. M. S. Mani, Agra were added to the Collection.

(ii) 4 species of Bostrychidae (Coleoptera) were added to the Collection.

(iii) One species comprising 21 specimens of Orthoptera were added to the Collection.

(iv) One species of *Phoracantha septempunctata* (Coleoptera : Cerambycidae) received from Israel, *Locusta migratoria migratorioides* R. & F. from London and 5 species of Formicidae (Hymenoptera) from California, not so far represented in the Collection, were added. Two American forms—*Schistocerca americana* (Drury), *Melanoplus differentialis* (Thom.) were added to the exotic collection of the National Pusa Collection.

(B) Donation of Insect specimens to Institutions :

38 species and 81 specimens as well as 8 living species of insects belonging to different orders were donated to various entomologists, state departments of agriculture, scientific and educational institutions.

(C) Donations of Insects received :

37 species of insects from Capt. R. K. Chopra from Kawat Expedition, Kashmir.

(D) Exchange of Insect specimens :

56 species of Lepidoptera (Butterflies) and 1 sp. (4 specimens) of Coleoptera were sent to specialists in England in exchange for insect specimens of these orders.

(E) Advisory :

(1) *Identification of insect specimens*.—During the year under report 263 species of insect pests, predators and parasites of different orders were identified for various state departments of agriculture, institutions and other individuals.

(2) *Supply of informations*.—Information relating to various insects of economic importance, their distribution, food plants and control measures was supplied to different institutions, scientific workers and private individuals. Information regarding the control of rats was also supplied to various institutions. Literature on insects of economic importance and their control was given to various scientific workers and facilities and help were given to students from various universities in the collection and consultation of literature as also identification of insect specimens.

76 coloured plates of insect pests were supplied to different workers and institutions.

(F) Delhi Intensive Cultivation Scheme :

Under the Delhi Intensive Cultivation Scheme organized by the Ministry of Food and Agriculture, the staff of the Division visited the neighbouring villages for investigation, survey and estimation of damage caused by the insect pests and rats to the field crops. Control measures were also carried out against the 'Kutra' (*Amsacta* sp.), termites, ants, the paddy 'Gundy Bugs' (*Leptocorisa varicornis*), the 'Singhara Beetle' (*Galerucella singhara*), the 'Painted Bug' (*Bagrada cruciferarum* Kirk.), 'Red pumpkin beetle' (*Aulacophora* spp.) and the 'Cutworms' (*Agrotis* spp.). A large number of rat holes were also fumigated with cyanogas and the method of fumigation was demonstrated to the villagers.

(G) Work at Sub-Stations :**(1) At Karnal—**

(a) *Bioclimatic studies in population fluctuation*.—Collection of weekly bioclimatic data on the population fluctuation of the spotted bollworm of cotton was continued as in previous years for the last twelve consecutive years. The overall analysis of the twelve years' data is yet to be taken up and completed.

(b) *Control measures*.—Control measures against *Leptocorisa varicornis* in an area of 192 acres of paddy fields in the Farm was carried out and 5-7½ per cent BHC was dusted. The work was done in collaboration with the staff of the Directorate of Plant Protection, Quarantine and Storage. Wheat stores in bags were dusted with Geigy 33 (10 per cent DDT dust). Baits of zinc phosphide were used against rats.

(2) *At Pusa*—

The survey of insect pests attacking field crops at the Farm was maintained throughout the year as also the occurrence of various predators and parasites was recorded and reported to the headquarters at Delhi. Control measures were undertaken against infestation by aphids and cutworms (*Agrotis* sp.). Baiting with zinc phosphide and "Warfarin" was carried out against rats.

II. RESEARCH INVESTIGATIONS

SECTION OF PARASITOLOGY

The Head of the Division continued to be incharge of this Section in addition to some other research activities which included investigations under Apiculture and the two Schemes of the I. C. A. R. namely, the DDT Scheme and the Termite Scheme.

A. Fundamental Studies :

1. *Bionomics and skeleto-muscular mechanisms of Lestodryinus pyrrillae* Kieff. (*Dryinidae* : *Hymenoptera*).—The bionomics, some important aspects of the morphology and the musculature of the head and the thoracic region have been studied in detail. The whole work has been written up in the form of a thesis.

2. *Effect of alternate hosts on the sex-ratio of Stenobracon deesae*.—Studies have shown that rearing the parasite on its natural host *Chilo zonellus* gave rise to a good percentage of females generation after generation while those reared on the alternate laboratory host *Corcyra cephalonica* stopped producing females completely after the second generation. Obviously *Corcyra cephalonica* does not appear to be a suitable host for the purpose of mass multiplication of this parasite in the laboratory.

3. *Effect of refrigeration of pupae on the pigmentation of the adult Bracon brevicornis* Wesm.—Observations on the refrigeration of *Bracon* pupae at $10^{\circ}\text{C} \pm 3$ for different durations showed that the viability, fecundity, longevity and sex-ratio of the progeny were highly reduced as the duration of refrigeration was increased from 5 to 30 days. The viability of pre-and one day old pupae was almost nil. The low fecundity of the adults that emerged from the refrigerated pupae was correlated with the retarded growth of the ovaries.

4. *Studies on some factors influencing the sex-ratio of hymenopterous parasite under mass breeding conditions.*—Size and instar of the host, temperature, humidity, in-breeding and cross breeding, restraint on the part of the female to lay eggs, intensity of light and the type of food given to the adult parasites are some of the factors that govern the sex-ratio of the parasite under mass breeding conditions. Studies are in progress on these factors on the development of *Bracon gelechiae* that generally showed preference to larger hosts for egg-laying and a higher percentage of female emergence from the natural host *Chilo zonellus*. A temperature of 25°C and humidity of 60 per cent was found optimum for the high sex-ratio in the progeny. With restrain for 24 hours the percentage of females of the progeny increased though its egg-laying capacity decreased at the same time. Bright light and protein food increased the percentage of females in the progeny.

5. *The biology, bionomics and rate of reproduction of Apanteles angaleti Mues., a parasite of Platyedra gossypiella Saun.*—For the first time in the history of the world Narayanan and Subba Rao successfully evolved a technique for the breeding of the parasite on the laboratory host *Corcyra cephalonica*. A temperature of 25°C and a relative humidity of 90 per cent was found optimum for the successful breeding of the parasite.

Studies on the life-history of the pest showed that the fecundity of the parasite increased from 24 to 38 eggs on the minimum side with the increase in the number of host supplied from 10 to 20; the corresponding increase on the maximum side being from 93 to 170 under similar conditions. The incubation period was 24 to 48 hours at 25°C, the eggs having failed to hatch at 35°C. The first two instars of the developing larva is spent internally within the body of the host and the third instar outside. The larval and pupal periods occupy from 24 to 31 and 4 to 7 days respectively under optimum conditions. The total life-cycle varies from 28 to 40 days.

6. *Studies on the immature stages of the genus Bracon and the genus Stenobracon.*—Studies on the immature stages of the various species show that the most distinguishing character is the chaetotaxy of the larva.

7. *Studies on Indian Ichneumonidae.*—Ichneumonidae is a parasitic family of great economic importance in the biological control of insect pests.

Sub-family Pimplinae was taken up. Tribes Rhyssini, Poemeniini and Ephialtini were created for the first time in India in accordance with recent trends in the taxonomic work of this family. Catalogues of the tribes Rhyssini, Acaenitini and Ephialtini were completed. Work on the tribes Xoridini and Poemeniini was in progress.

Similarly Sub-family Banchinae was taken up. The Catalogue of the tribe Lissonotini was completed. Sub-families Plectiscinae, Metopiinae and Collyriinae were created for the first time in India in accordance with the recent trends in the taxonomic work of this family. Work regarding these sub-families was in progress. Synopsis of the Sub-families Collyriinae, Mesochorinae, Plectiscinae Metopiinae and Gelinae was taken up in hand.

Host index regarding the family Ichneumonidae was completed and Ichneumonid parasites were found to belong to the sub-families Pimplinae, Ophioninae, Diplazoninae, Banchinae, Metopiinae, Mesochorinae, Tryphoninae, Ichneumoninae Plectiscinae and Gelinae.

B. Biological control of insect pests (Mass breeding of parasites)

(1) *Trichogramma evanescens minutum* Riley.—During the year under report about 3.15 million parasites were bred on the eggs of *Corcyra cephalonica*. About 128,000 and 24,000 parasites were sent to the Government Entomologists, Madhya Pradesh and Madhya Bharat respectively.

(2) *Bracon gelechiae* Ashm.—About 28,000 parasites were reared on the laboratory host *Corcyra cephalonica*. 400 parasites were sent to the Secretary, Potato Cultivators' Association, Patna. About 200 parasites were also sent to the Government Entomologist, Bangalore.

(3) *Apanteles angaleti*.—The culture of this parasite is being maintained.

(4) *Corcyra cephalonica* (Host).—During the year under report 208,000 moths were reared and 650 c.c. of eggs obtained. 433 c.c. of eggs were used for culture purposes and the rest for the breeding of *Trichogramma* parasites. 1 c.c. of eggs was sent to Shri Upadhyaya, Professor of Agriculture, Gwalior.

C. Apiculture :

The unfavourable season was generally from November to February when the population of the bees in the colonies fell down due to severe cold. There was attack on the colonies during this period by the wax moth, *Galleria mellonella* Linn. and for which the empty and surplus combs were removed from the brood chamber and the floor-boards of the hives had always to be kept clean. The bees were fed on dilute honey once in a week and were also kept warm by using some sort of a quilt. By about the end of February the population of the bees in the colonies began to increase and from March to June it was indeed a very busy season for the bees with a rapid multiplication and starting of the swarming fever. The colonies were examined periodically and all possible cares were taken to prevent swarming. During the active brood season too many of drones and drone broods were formed in the colonies and these excess drones or drone broods were all destroyed. June was slightly a bad period because of the dry weather dust. From July to September the population was maintained well and the activity of the bees increased again in October, this month being the best period for the bees. There was again a tendency for swarming but that eventually faded away with the approach of the cold season. The flowers from which the bees collected nectar and pollen in Delhi State were recorded.

SECTION OF SYSTEMATIC ENTOMOLOGY

(1) Studies on the male genitalia of some of the Indian Thysanoptera were taken up and completed. Detailed study of the genital structures of eight genera comprising 15 species was made. The studies revealed that the genitalia presented structures which were of diagnostic value. The findings have been sent in the form of a paper for publication.

(2) Studies on the Systematics of Indian Curculionidae were taken up and the sub-family Otiorrhynchinae of considerable economic importance was being studied. A catalogue of this sub-family was under preparation. The catalogue will enlist all genera and species found and recorded from India, Pakistan, Burma and Ceylon. A list of the species of this sub-family existing in the National Pusa Collection was made. Preliminary studies of the identified and named specimens were also completed and the identification of unidentified specimen was taken up. The studies are in progress.

(3) The external morphology of the Indian Catantopinae represented by 11 genera and 31 species in the National Pusa Collection was studied. The studies on male and female genital structures of 21 species out of the total number of available species were also taken up. A tentative relationship between the Elytron/Hind Femur ratio in the gregaria and solitaria forms and the relative length of the Lophi (paired posterior process) of the epiphallus in the case of the male *Schistocerca* Forskal was established for the first time. The findings appear to be of importance in supplying additional characters for determining the phases of a particular specimen. One species of *Oryza* found in the unidentified materials was traced to be new to science and has been described. The male genitalic structures of *Schistocerca americana* (Drury) specimens of which were received through the courtesy of Dr. J. A. G. Rehn, Philadelphia, U.S.A. were compared with that of the *Schistocerca gregaria* Forskal and details in the differences in the two genitalia were recorded. The studies on the genitalia of other genera and species establish that the genitalic structures are useful in differentiating various species and genera.

(4) The systematic study of the important crop pests belonging to the family Noctuidae (Lepidoptera) better known as Cut-worms group was taken up. Twenty five Indian genera comprising 85 species were studied so far. Besides studies on the external morphological structures, the studies on the genitalic armatures of both males and females were conducted. These studies have been very useful in the determination of interrelationship of the various genera and their species. Indian genera such as *Plusia*, *Euplexia*, *Leucania*, *Agrotis*, *Amyna* and *Eublemma* contain certain species whose genitalic structures show that they should be removed from their respective genera to which they have been assigned. The studies on certain species of *Euxoa* and *Agrotis* on the other hand, indicate marked similarity. As such, the regrouping of these species are to be considered.*

(5) Studies on the male genitalia of 4 genera of Eumeninae (Hymenoptera : Vespoidea : Vespidae) comprising 20 species were completed. The genitalic structures show that the genera *Rygchium* and *Odynerus* are to be considered as synonymous though the latest works even now maintain that the two are separate genera. In view of the general plan of their genitalic structures being similar, the pygidium and hypopygidium were also studied but these differences appear to be insignificant.

The catalogue of Eumeninae has been completed. This catalogue covers all Eumenid wasps which are found in the Oriental Region and it has been noted that so far there exist 18 genera comprising about 264 species, sub-species and their varieties.

The work of writing up a catalogue of the allied sub-family of Vespinae was also taken up and all forms of the Oriental Region are being incorporated into it. The work is being continued. Studies on the systematics of this sub-family has also been taken up and a new variety of *Polistes hebraeus* has already been found and is being described.

(6) *Systematic studies on Reduviidae*.—Reduviidae or the family of assassin bugs consists of predators and phytophagous forms. It includes 12 sub-families which have 3-jointed rostrum in all cases except in Nabidinae where there are 4 joints. Further, eyes are well separated from the anterior margin of pronotum in all except in Nabidinae, where the eyes are sunk in the head. Since the National Pusa Collection contains many representatives of the sub-families, a study of this group was taken up to determine those species whose systematic position is not known.

SECTION OF ECOLOGY AND TOXICOLOGY

I. Bioassay of Insecticides

(i) *Relative toxicity of fumigants to storage pests*.—Observations on the relative toxicity of hydrogen cyanide, methyl bromide, carbon disulphide, chlorosol, ethylene dichloride and carbon tetrachloride to the grubs of *Trogoderma granaria* and adults of *Tribolium castaneum* and *Bruchus* sp. showed that the relative toxicity of the various fumigants based on L.C. 50 were in the order of hydrogen cyanide>methyl bromide>carbon disulphide>chlorosol=ethylene dichloride>carbon tetrachloride. *T. granaria* proved to be most resistant and *Bruchus* sp. most susceptible to all fumigants, *T. castaneum* holding an intermediate position.

(ii) *Relative toxicity of insecticidal dusts and films to storage pests*.—The comparative toxicity of six insecticidal dusts viz., DDT, BHC, aldrin, dieldrin, toxaphene and chlordane to *Tribolium castaneum*, *Calandra oryzae* and *Bruchus* sp. and that of six insecticidal films to *T. castaneum* and *Bruchus* sp. were studied. Based on L. C. 50 dieldrin dust proved to be most toxic to *T. castaneum* and *Bruchus* sp. while gamma BHC dust proved to be most toxic to *C. oryzae*. As films, aldrin was found to be most toxic both to *T. castaneum* and *Bruchus* sp.

Two preliminary experiments showed that the multiplication of *Trogoderma granaria* and *Coreyra cephalonica* could be kept effectively under check by mixing DDT or toxaphene dusts at the rate of 20 to 80 p.p.m. or gamma BHC, aldrin, dieldrin or chlordane at the rate of 10 to 40 p.p.m. approximately.

(iii) *Preliminary tests of chemicals synthesised in the Chemistry Division*.—Observations on the relative toxicity of six chlorinated terpene products using *Tribolium castaneum* adults as test insects showed: that technical toxaphene>chlorinated delta 3 carene>chlorinated pinene>chlorinated terpine oil>chlorinated longifolene.

(iv) *Toxicity of insecticidal sprays to Leptocorisa varicornis*.—Six modern insecticides and pyrethrum were tested at five different concentrations in the laboratory for their toxicity to Gundhy bug (*Leptocorisa varicornis*) on paddy. All the insecticides brought about practically 100 per cent mortality within 24 hours.

II. Relation between changes in susceptibility and various factors connected with successive instars of the Desert Locust

That older instars of insects generally prove harder to insecticides than younger ones is, by now, a fairly established fact but the factors responsible for this increase in resistance have received little attention. The present investigation was an attempt to explore these factors in the case of Desert Locust, *Schistocerca gregaria* Forsk.

Of the twelve factors studied, three viz., (a) surface area per unit weight, (b) percentage of wax in the exuviae, and (c) the probable thickness of the exuviae (which is also probably an index of the thickness of the cuticle), are most likely to affect the entry of the insecticide in different instars.

III. Studies on Control Schedules

A replicated field experiment was carried out in order to evolve a schedule of control operations against aphid infestation in mustard crop. Six insecticidal spray formulations were chosen for trial. Spraying was carried out whenever the aphid infestation in any treatment indicated a necessity for the same. The number of sprayings was different with different treatments. The aphid population was estimated both before and after each spraying. The mean yields obtained from the different treatments, however, did not show any significant difference.

IV. Effect of ecological factors (temperature) on toxicological response (susceptibility)

(i) Post-treatment temperature coefficient of insects resistance to insecticidal sprays.—

It has been shown by this section earlier that in the study of the effect of temperature on insects' mortality due to insecticides the factor of temperature should be differentiated into three components viz., (a) pre-treatment temperature, (b) treatment temperature and (c) post-treatment temperature.

This year it has been possible to demonstrate, for the first time so far as known to us, by quantitative experimental data the graphical relation between post-treatment temperature and what may be called insects' resistance to insecticides. The regression equations and the values of LC 50 for six different formulations viz., DDT emulsion, DDT suspension, BHC emulsion, toxaphene emulsion, chlordane emulsion and parathion emulsion under different post-treatment temperatures, and using *Tribolium castaneum* adults pretreated for 24 hours at about 14°C as insect material have been studied. The relative humidity was maintained between 50 and 55 per cent at all temperatures. The values of LC 50 were calculated, however, only on the basis of mortality counts on the fourth day after spraying. There are two important points arising out of these observations to which it is necessary to draw special attention:

1. Our expectation that an increase in the post-treatment temperature within limits should decrease the toxic effect has been clearly realised for the first time during the present investigation in three out of six formulations. However, possible cause for divergent results with different insecticides or with the same insecticide under different conditions require to be investigated.

2. There is an interesting similarity between the curves obtained by plotting the values of LC 50 for DDT and gamma BHC formulations against different post-treatment temperatures and the curves published by various workers connecting temperature with various physiological activities.

(ii) *Treatment temperature coefficient of insect resistance to insecticide film.*—Only preliminary studies were carried out on this topic. DDT films of five strengths were made on the glass surface of petri dishes, and adults of *Tribolium castaneum* were confined on them for two hours at four different temperatures. There was higher mortality in insects kept on DDT films at higher temperature.

V. Ecological studies on Phadka (*Hieroglyphus nigrorepletus* Bol.)

The following aspects of the pest were studied :

(i) *Viability of eggs.*—This year after many trials and errors a process of separating the eggs from the pod has been evolved. It is rather interesting that whereas soaking the eggs in water for days together does not bring about any softening of the egg pod, the keeping of the same in moist soil for about 8-10 days softens the pods to a great extent. The number of eggs studied by this new method varied from 23 to 52 giving an average of 39 eggs per pod. About 70 per cent of these eggs are viable.

(ii) *Diapause studies.*—A special attempt to break the diapause was successful for the first time. Eggs laid in 1952 were kept at a temperature varying between 10-12°C for 2 months. Subsequently these were removed and placed under soil in earthen pots at temperature varying between 30-32°C. The pots were watered after every 2 days. This resulted in the emergence of nymphs from the eggs laid in 1952 as early as 27th March, i.e. 2½ months before their usual time of emergence.

(iii) *Effects of temperature on the nymphal periods of the pest.*—These studies were carried out at 20°, 25°, 30°, 35°C and 50 per cent and 75 per cent R.H. The first instar nymphs did not survive at 50 per cent R.H. at all the above temperatures. Also no nymph survived at 20°C in both the humidities.

VI. Studies for the construction of Biometer for *Trichogramma evanescens minutum* Riley.

The rearing of these parasites was carried out at 12°, 18°, 25°, 30° and 35°C and at 35 per cent and 75 per cent R. H. Based on the data collected so far the following equation connecting temperature and developmental index was worked out :

$$Y = 16.35 e^{-0.0041104 (34.8 - t)^2}$$

Where Y is the developmental index

e is the base of Napierian logarithm

t is the temperature in centigrade.

Starting with this equation the temperatures (t) corresponding to different values of developmental index were calculated, and a biometer was constructed for trial purposes.

I. C. A. R. SCHEMES

1. Scheme for tests with DDT, 666 & Allied Insecticides

Studies on the effect of DDT mixed in different doses in the soil on the incidence of termite attacking sugarcane support the same view as held in last year in that there was no correlation between the treatments of DDT and the termite incidence.

Laboratory sprayings done with DDT, gamma BHC, parathion and pyrethrum emulsions in different strengths, with *Trogoderma granaria* larvae as the test insect showed that only pyrethrum, used at a concentration higher than 0.5 per cent gave some positive results. There was no mortality in *Trogoderma* larvae that were sprayed with DDT up to 10 per cent, BHC up to 3 per cent, parathion up to 0.3 per cent and Follidol (commercial parathion) up to 0.4 per cent.

Studies made on the persistence of DDT (2 per cent and 1 per cent), BHC (0.5 per cent), dieldrin (0.25 per cent and 0.125 per cent) and toxaphene (0.5 per cent) emulsions sprayed on castor showed that there was 100 per cent mortality amongst *Euproctis lunata* larvae that were fed with the castor leaves sprayed with these insecticides of different strengths respectively even up to 50, 10, 26 and 26 days of spraying. The mortality in the control was *nil* under similar conditions.

A series of tests had been in progress on the viability and freedom from pests of stored grains like wheat NP 165, Barley NP 13, Gram NP 58, Maize yellow 2 and Rahar (mixed) treated with different doses of DDT, gamma BHC and pyrethrum dusts (both commercial and laboratory made) and stored under normal conditions in the godowns from harvest to sowing time. The whole data is under statistical analysis.

The observations made on the control of the bollworms of cotton by DDT and BHC spraying confirmed last year's results regarding the detrimental effects on the buds and bolls of cotton due to DDT sprayings at two weekly intervals. Moreover the control of the bollworms was also not very effective.

2. Scheme for Research on Termites

- I. *General survey of the whole country with regard to (a) the crop plants including fruit trees infested by different species of termites, (b) the nature of soils where crops are infested, and (c) climatic conditions of the infested localities, etc.*

Microtermes obesi, *Trinervitermes biformis* and *Termes assmuthi* were found damaging wheat, cotton and sugarcane respectively at Poona and Anand. The soil at Anand is sandy loam while at Poona it is black and non-alluvial. In Delhi State, hedge plants *Prosopis juliflora* and *Inga dulcis* seedlings were severely attacked by termites. Groundnut was damaged to an extent of 90 per cent.

- II. *Studies on the effects of various insecticides of synthetic and vegetable origin against attack on such important crops as sugarcane, wheat, cotton, etc.*

(i) *Wheat (NP 710).*—The insecticides tried against termites on wheat were (a) a mixture of technical DDT and technical BHC dust (50 : 50) and (b) technical toxaphene dust, with four dosages of each insecticides, viz. 5 lb/acre,

10 lb/acre, 15 lb/acre and 20 lb/acre. Thus there were nine treatments including control, replicated six times in randomised block.

A mixture of technical DDT and technical BHC dust (50 : 50) and technical toxaphene dust at the rate of 20 lb/acre brought down the damage by termites from 34 per cent in control to 2.9 per cent and 3.6 per cent in the treated plots respectively.

(ii) *Sugarcane (Co 312)*.—The insecticides experimented upon were (a) a mixture of technical DDT and technical BHC dust (50 : 50) and (b) flake dieldrin dust given in furrows before planting; with three dosages of each insecticide, viz. 5 lb/acre, 10 lb/acre, and 15 lb/acre. And three concentrations of a mixture of 50 per cent wettable DDT and 50 per cent wettable BHC (50 : 50) in water, viz., 1.5 per cent, 2.0 per cent and 2.5 per cent were used for dipping treatments of cane setts. Thus there were ten treatments including control replicated four times in randomised block.

From the observations recorded hitherto it is obvious that 10 lb/acre dose of each of the mixture of technical DDT and technical BHC dust (50 : 50) and dieldrin dust has controlled termite incidence from 37.6 per cent in control (untreated) to 3 per cent and 2.1 per cent in the treatments respectively and the percentage of germination in the above treatment was 71 per cent and 72.5 per cent respectively while in control 53.7 per cent. The experiment is still in progress.

(iii) *Cotton (F 216)*.—The insecticides tested were (1) technical DDT dust, (2) technical BHC dust and (3) flake dieldrin dust, with three dosages of each insecticide, viz. 5 lb/acre, 10 lb/acre and 15 lb/acre. There were ten treatments including control, replicated four times in randomised blocks.

From the preliminary observations obtained so far it appears that technical BHC dust at 15 lb/acre, flake dieldrin dust at 10 and 15 lb/acre reduced the termite damage from 14.9 per cent in the control to 2.2 per cent, 1.8 per cent and 1.4 per cent in the treated plots respectively. The experiment is still in progress.

III. *Studies on the Biology and habits, etc. of the species affecting different crops, specially wheat, sugarcane, cotton, etc.*

Termite soldiers and workers (*Odontotermes* sp.), when kept at a room temperature of 27-29° C in the termitarium soil (initial moisture content 9.97 per cent) obtained at a depth of 2½' to 3' were dead on the 3rd day, while in fixed temperature of 27°C ($\pm 1^\circ\text{C}$) and under 75 per cent to 80 per cent relative humidity they could live from 4 to 5 days in the above soil. But when kept in an incubator at a temperature of 18° C ($\pm 1^\circ\text{C}$), the workers died on the 2nd day while the majority of soldiers died within 4 days and only one soldier could survive for 7 days. The initial moisture content of the termitarium soil on dry weight basis was 9.239 per cent in the latter experiment.

PROGRAMME OF RESEARCH WORK OF THE DIVISION OF ENTOMOLOGY FOR THE YEAR 1954-1955.

I. Section of insect parasitology

A. *Fundamental studies on insect parasitism*

- (i) Field trial studies of biological control of *Chilo zonellus*.

- (ii) Effect of different nutrition on the fecundity and longevity of *Bracon brevicornis* Wesm.
- (iii) Breeding DDT resistant strain of *Bracon gelechiae*.
- (iv) Biology and Bionomics of *Bracon chinensis* Szep.
- (v) Control of pink bollworm by means of their natural enemies.
- (vi) Some aspects of the embryology of *Tetrastichus pyrillae* Craw.
- (vii) Biology of *Aegeniaspis pyrillae* Mani—a chalcid egg parasite of *Pyrilla* sp.

B. Preparation of a catalogue of insect parasites and predators of major pests of agricultural crops in India.

C. Apiculture.

II. Section of insect taxonomy and morphology

- 1. Revision of Arctiidae and Geometridae (Lepidoptera).
- 2. Revision of Oedepodinae (Orthoptera).
- 3. Revision of Sub-family Otiorrhynchinae (Coleoptera : Curculionidae).
- 4. Systematic studies and preparation of Catalogue of Sub-family Vespinae (Hymenoptera : Vespidae).

III. Section of ecology and toxicology

- 1. Bioassay of Insecticides.
- 2. Studies on specificity of insecticidal action leading to rational formulations.
- 3. Evolution and control schedule (Pest : Mustard aphid).
- 4. Effect of ecological factors (temperature and Humidity) on toxicological response (susceptibility) of insects.
- 5. Studies on the construction and use of Biometer (Insect : *Trichogramma evanescens minutum*).
- 6. Development and distribution of insects under different ecological conditions (Phadka : *Hieroglyphus nigrorepletus* and *Chilotrea infuscatella*).

IV. I. C. A. R. Schemes

- 1. Tests with DDT, 666 and Allied Insecticides.
- 2. Termite Research.

V. Miscellaneous and routine observations**1. Observations on Indian insects of economic importance**

- (a) Pests of crops at I.A.R.I. and in the neighbouring villages to assist local cultivators in controlling the pests (including rodents) under the Delhi Intensive Cultivation Scheme.
- (b) Fruit pests.
- (c) Pests of potato.
- (d) Pests of sugarcane and their natural enemies.
- (e) Predators and parasites in general.

2. Studies on immature stages to fill up certain lacunae.

REPORT OF THE DIVISION OF MYCOLOGY AND PLANT PATHOLOGY FOR THE YEAR 1953-54

(DR. R. S. VASUDEVA)

The Division of Mycology and Plant Pathology continued to work on the study of plant diseases caused by pathogenic organisms including fungi, viruses and bacteria with a view to devising methods for their control and evolving disease-resistant varieties of crops in collaboration with the Division of Botany. The training and teaching of postgraduate and undergraduate students was also continued.

A brief account of the principal activities of the Research Projects carried out during the year in the various Sections of the Division and its Substations is given below :

RESEARCH

A.—Section of Plant Pathology

1. Wheat

(a) *Rust* (*Puccinia graminis tritici* (Pers.) Erikss. and Henn., *P. triticea* Erikss., *P. glumarum* (Schmidt) Erikss. and Henn.) —Studies on the physiologic races of black, brown and yellow rusts were continued. In all, 282 collections of rusts, obtained from different parts of the country, were analysed which yielded races 21, 34, 40, 42, 194 and C of black rust, races 10, 11, 20, 26, 63, 106, 107 and 108 of brown rust and races 19, 31, A and D of yellow rust. Race C of black rust, which is closely allied to race 72, was isolated on wheat variety Kenphad-28 from Coimbatore for the first time. Indications of a new race of brown rust have also been obtained. Races 21, 40 and 42 of black rust, 20 and 63 of brown rust and 19 and A of yellow rust were predominant and widely distributed throughout the country. Race 34 of black rust appears to be increasing in its prevalence, whereas race 42 is on the decline. Colour mutation in race 15-C of black rust has been observed. The mutant differs from the parent culture in having dull orange colour and longer incubation period, but not in virulence.

A search for the collateral and alternate hosts for the rusts was continued in the hills of Punjab, Bombay, Mysore and Himachal Pradesh. Rust collections from 38 wild grasses from different parts of the country did not reveal any new collateral host. More than 90 grass samples, raised from seed, were artificially inoculated with a mixture of races of black rust, but none of them took infection. Of these, 46 collections were also tested with brown rust, but without any success. *Vulpia myuros* was successfully infected with races 15, 15-C, 24, 42-B and 194 of black rust, producing resistant type of infection, whereas *Briza minor* did not get infected.

Evidence of oversummering of black and brown rusts in the Western Ghats at Panchgani and Mahabaleshwar was obtained, thus indicating the possibility of local foci of infection for the wheat crop of Bombay State.

In aerobiological studies, aeroscope slides from seventeen rust nurseries were examined and in 12 cases, spore showers were significant for the outbreak of black rust and 3 each for brown and yellow rusts. At two nurseries, namely, Pusa and Delhi, spores of brown and yellow rusts were also observed on the slides before the outbreak of the rusts, but these results cannot be relied upon in view of plenty of inoculum in the neighbourhood due to artificial inoculations at that time.

In the seedling resistance tests, in which about 22,000 plants were inoculated, all the 48 wheat varieties and crosses tested against individual races of black rust were found to be susceptible to one or more races. Wheat varieties E. 2025, N.P. 789, and N.P. 790 were found to be susceptible only to race 122, and E. 931 to race 15-C. Forty-seven wheat varieties and crosses were also tested for their seedling resistance to brown rust and varieties E. 928, E. 931, E. 952, E. 957, E. 1951, E. 2025, E. 2158 and N. P. 815 were found to be resistant. In the case of yellow rust, 41 wheat varieties, crosses and hybrids were tested against individual races and varieties E. 630, E. 687, E. 740, E. 928, E. 938, E. 952 and H-D.(52)-30 proved to be resistant. But the results of yellow rust require further confirmation as tests with some races were conducted when the conditions were not quite favourable for the development of the rust. The following wheat varieties were found to be resistant when tested against a mixture of races of the three rusts separately; black rust—E. 1928; brown rust—N.P. 813, I.C. 1057, E. 1044, E. 1809, E. 1818, E. 1823, E. 1841, E. 1844, E. 1849, E. 1867(A), E. 1944, E. 2140, E. 2152, E. 2224, E. 2259, E. 2295, and (N.P. 710 × E. 957) F_1 ; yellow rust—C.L.11, C. 250, E. 1844, E. 1928, E. 2128, E. 2295, N.P. 814, N.P. 722, N.P. 723, Padava I and Padava II.

In the adult resistance tests, more than 83,000 plants were examined in the field for their rust resistance after artificial inoculations with a mixture of races of each of black, brown and yellow rusts or with the complex mixture of all the races of the three rusts. About 1,300 resistant varieties, crosses or plants have been selected for further study.

Different agricultural and manurial treatments did not show any difference in the rust incidence.

(b) *Loose Smut* (*Ustilago tritici* (Pers.) Rostr.).—Out of 125 wheat varieties tested for their resistance to loose smut at Delhi, 72 proved to be resistant as they did not show any infection, 12 were moderately resistant with infection less than 5 per cent, and the remaining 41 behaved as susceptible with infection more than 5 per cent. In similar tests conducted at Simla with 20 wheat varieties, 17 reacted as resistant and 2 as susceptible.

For physiologic forms study, 10 collections of loose smut were tested on 13 wheat varieties, including the standard differentials, but the results obtained cannot be considered conclusive as some of the differentials did not flower.

(c) *Bunt* (*Tilletia foetida* (Wallr.) Liro and *Neovossia indica* (Mitra) Mundkur).—The European bunt fungus, *Tilletia foetida*, was brought into culture. The percentage of infection obtained in wheat varieties N.P. 770, N.P. 801 and N.P. 809, when seed was artificially infested with chlamydospores at the time of sowing, was 41.80 and 67, respectively.

Karnal bunt (*Neovossia indica* (Mitra) Mundkur) was observed in an epidemic form this year in Delhi State as also in some other neighbouring districts of the Punjab and U. P. The wheat variety Punjab C. 591 was the worst affected and comparatively greater infection was observed in the irrigated tract than in the *barani* crop. Furthermore, the number of infected grains in the diseased ears and the intensity of infection in individual grains were much greater than hitherto considered. Wheat crop, raised from seed (N.P. 718) treated with Agrosan GN, showed a very low percentage of infection as compared to that raised from untreated seed.

2. Barley

Rust (*Puccinia graminis tritici* (Pers.) Erikss. and Henn. and *P. glumarum* (Schmidt) Erikss. and Henn.).—Seventeen rust collections of barley, obtained from different parts of the country, were analysed which yielded races 21 and 34 of black rust and races 19 and A of yellow rust. Fifteen barley varieties were tested against individual races of black and yellow rusts in the seedling stage, but none was found to be resistant. In the adult resistance tests, barley varieties B. 70 and B. 75 were found to be resistant to a mixture of all the ten races of yellow rust.

3. Sugarcane

(a) *Red Rot* (*Colletotrichum falcatum* Went).—Localised epidemics of red rot in certain areas of Jagadhari, Sonapat and Ambala (Punjab) were reported. The perithecial stage (*Physalospora tucumanensis*) of the fungus has been found to occur at Delhi and Karnal as also at a few other places in the Punjab where search was made. The connection between the ascigerous and conidial stages was established. This finding opens up a new line of investigation regarding the origin of new and more virulent strains of the red rot fungus in nature.

Thirty-two isolates of *Colletotrichum falcatum*, collected from different cane growing tracts of the country, were tested on ten standard cane varieties, with different genetic composition, but no evidence of physiologic specialization within the fungus was obtained. In general, the dark coloured isolates were less virulent than the light types.

In the varietal resistance tests, 201 cane varieties were tested by the standard Plug method and 111 through nodal regions with *C. falcatum* isolate No. 244. No variety was found to be resistant. Forty-one varieties behaved as moderately resistant by the Plug method and 3 varieties when inoculated through the nodal regions. The remaining varieties were considered as susceptible.

As regards the relative resistance of cut and standing canes to red rot, it was observed that 16 varieties gave more infection in cut canes and two in the standing canes. In the experiment to study the beneficial effect of sulphur application at the time of planting on the resistance of cane to red rot, two varieties showed the same amount of infection in the sulphur treated and untreated crops, two gave less infection in the treated plots than the control, whereas six showed greater infection in the treated plots. Evidently the application of sulphur at the time of planting does not increase the resistance of the crop to red rot. Studies on the relative resistance and susceptibility of plant and ratoon crops showed that the first year

ratoon crop generally gave more infection than either the plant crop or the second year ratoon crop.

Experiments to study the varietal resistance to red rot and smut in sugarcane were continued at Coimbatore and 79 "G" numbers, 75 "P" numbers and 81 *Spontaneum* collections were suitably inoculated for the purpose. Varietal resistance tests, with locally important and promising cane varieties of Punjab, were also carried out at Jullundur and Jagadhari for the Economic Botanist (Sugarcane), Punjab.

(b) *Smut (Ustilago scitaminea* Syd.).—In the varietal resistance tests, sets of 98 cane varieties at Delhi and 99 at Karnal were inoculated with smut spore suspension and then planted in the field for observation. At Delhi, three varieties showed less than 5 per cent infection, one showed 5-15 per cent infection, three gave 15-30 per cent infection and the remaining 91 varieties showed 30-100 per cent infection. The corresponding figures for the Karnal experiment were 21, 17, 10 and 51. Twenty-four varieties, namely, Co. 612, 776, 787, 805, 810, 813, 819, 820, 822, 832, 847, 871, 879, 888, 890, 897, 913, 922, 928, 930, 931, 947, P. 4626 and P. 4628, which showed less than 5 per cent infection, may be considered as resistant.

4. Linseed

Rust (Melampsora lini (Pers.) Lev.).—Nineteen samples of linseed rust, collected from different parts of the country, were analysed which yielded all the four races of *Melampsora lini* so far reported from India. In addition, a new race from the Punjab collections has been obtained. The new race differs from the existing four races in its reaction on the auxiliary differential *Argentine Selection* C.I. 705-1.

In the varietal resistance tests with 30 linseed varieties, including 10 varieties received from Dr. H. H. Flor, the following were found to be resistant or immune: B. 5128 (C. I. 980), Marine (C. I. 135), Victory (C. I. 145), Rio (C. I. 280), Sheyenne (C. I. 1073), Kota (C. I. 892), Dakota (C. I. 1071), Golden (C. I. 981) and R. R. numbers 5, 37, 40, 45, 197, 204, 236, 262, 267, 402, 431, 439 and 440. Out of 94 varieties tested against a mixture of the four races in the seedling and adult stages, 53 varieties proved resistant or immune, 19 as semi-resistant and 22 as susceptible.

Linum trigynum, *L. marginale*, *L. africanum*, *L. angustifolium* and *L. coeruleum* were found to be immune when tested against a mixture of the four Indian races, showing thereby that they cannot act as collateral hosts for the linseed rust.

5. Pigeon-pea

Wilt (Fusarium udum Butler) —Twenty selected pigeon-pea varieties, received from the Botany Division, were tested for wilt resistance both in pots and wilt-sick plot. Sixteen varieties showed infection in pots and 8 in the field trial. Varieties N.P. 41, C. 15 W. E. and N.P. 69 × U.P. 132, 3-2-2-2 proved resistant as they did not show any infection either in the field or in pots. Of these, N.P. 41 has consistently shown high resistance since 1945.

6. Bajra

Green-Ear (Sclerospora graminicola (Sacc.) Schroet.).—Experiments in pots and field were in progress to study the viability of oospore material of *Sclerospora*

graminicola, which had been exposed for weathering since 1952, and the percentage of infection obtained was 4.4 and 3.5, respectively. Germination tests, conducted with such material, gave positive results but the germination percentage was very low. Oospore-infested soil, which gave successful infection last year and had been exposed to weathering conditions since then without the addition of any inoculum, gave 1.5 per cent infection again this year, thus indicating the persistence of the infection in soil and germination of the oospores at varying intervals. Germination of oospore material, collected from Rajasthan and other parts of the country, was being tested and conditions worked out under which better germination could be obtained. There was no improvement in the germination when the oospores were pre-treated with 10 per cent bleaching powder, or 5 per cent lactic acid for varying intervals.

7. Antibiosis

Studies on the inhibitory action of *Bacillus subtilis* on certain pathogenic organisms were continued. The biological spectrum of the antibiotic was investigated using 32 fungi and bacteria. The active principle did not have any action on bacteria, whereas it inhibited the growth of 7 out of 20 test-fungi. The action of the antibiotic was mostly fungistatic. In the case of *Alternaria solani*, however, it was fungicidal when the spores were pre-soaked in the culture filtrate for 24-48 hours. The autoclaved culture filtrate showed both the inhibitory and bulb-forming activities, the latter being negligible in the unautoclaved culture filtrate.

The unit of the substance showing bulb-forming activity was defined and the bioassay method using *Alternaria solani* spores standardized. Solvent extraction procedures were investigated and n isopropyl alcohol found to be a good solvent for the antibiotic. The substance was also found to be soluble in water, methanol and ethanol, but not in acetone and chloroform. Other properties of the antibiotic were also being studied. Up-take of the antibiotic by tomato plants was confirmed.

8. Physiology of fungal parasitism

Work on the physiology of some less specialized parasitic fungi e.g. *Fusarium solani*, *Fusarium fructigenum* and *Botrytis allii* was in progress. The parasitic activity of *F. solani* on potato was enhanced when a drop of Brown's synthetic medium was given in advance of inoculation. The omission of asparagin from the medium reduced its activity. An advance dose of Brown's synthetic medium did not, however, make it parasitic on onions. *Fusarium fructigenum*, which normally attacks only apples, was made to parasitise potato when an advance dose of enzyme extracts from *F. solani* was given before inoculation.

Phytophthora infestans was successfully grown in a liquid medium using peptone as a complex organic nitrogen source and carrot extract as a source of supplementary growth factor. The presence of preformed nitrogen compounds like amino acids was found to be essential for the growth. The vegetative growth was found to be quicker and more luxuriant on cherry extract agar than on maltose-peptone-carrot-extract agar. *Lophotrichus ampulius* was found to be heterotrophic for thiamin and possibly for pyridoxin. Sporulation of the fungus was demonstrated to be dependent on the availability of biotin. Presence of sucrose as a carbohydrate

source was also necessary for sporulation and substitution of sucrose with glucose inhibited sporulation in an otherwise complete medium.

Studies on plant tissue culture have been initiated. Safflower roots were successfully grown in Gantner's agar medium for six generations and substitution of sucrose instead of glucose gave better growth. Wheat roots, however, could not be grown after first generation in the same medium. Attempts to infect the safflower tissue culture with *Puccinia anthraci* (Safflower rust) have so far been unsuccessful.

9. Fungicides

Repeated field experiments were conducted to determine the relative efficacy of several commercial fungicides on the emergence, stand and yield of kharif, winter, barley and wheat. It was found that the fungicidal seed dressing in the case of maize gave only slight increase in yield. In kharif, in addition to a slight increase in yield there was an increase in germination and tillering. With wheat, a slight increase in average height of the crop was observed, but no appreciable increase in yield was found except in the case of Lanxan. In barley, however, a slight decrease in yield was observed with all the five fungicides tested.

Correlation of soil and seed microflora to pre-emergence injury in wheat and maize as also the beneficial effect of seed treatments were being studied. A species of *Helicoverpia* was predominantly associated with Delhi soils, whereas a species of *Alternaria* was isolated from wheat and maize seed. It has been shown that soil microflora do more damage than the seed microflora and that if seed microflora are eliminated without giving any subsequent protective covering to the seed the damage caused by the soil microflora is greater. Seed dressing with Syngon in the case of wheat and Agrosan GN in the case of maize proved comparatively more effective. Preliminary tests using *Trichoderma* species for seed dressing have given encouraging results.

10. Assessment of damage

In the case of sugarcane rust, the crop grown from sets obtained from untreated canes of U. 311 and U. 312 showed a reduction in yield of 45.8 and 34.6 per cent, respectively, while the corresponding figures of reduction in yield where the sets were inoculated at the time of planting were 7.6 and 23.4 per cent. Preliminary studies have shown a loss of about 27 per cent in the mosaic affected maize plants. As sugarcane rusts, about 20 per cent loss in yield on 1000 grain weight basis was observed with 60-80 per cent infection.

11. Bacterial diseases of plants

In the case of bacterial "Tundu" disease of wheat, the exact relationship between the bacterium (*Corynebacterium tritici*), the nematode (*Aegonema sativae*) and the host (wheat) was being determined. Reported isolations from the nematode galls yielded a yellow, gram-negative bacterium which was different from *C. tritici*. Histopathological studies revealed the presence of bacteria in the growing points of the infected wheat seedlings but not in nematode galls. Preliminary field tests were also in progress to determine the effect of rotation (soy, barley, fallow) on disease incidence.

Further evidence of the occurrence of strains of *Pseudomonas solanacearum*, the causal agent of brown rot of potatoes, was obtained. The Indian isolates differed from one another in chromogenesis, gelatin liquefaction, action on litmus milk and utilization of certain carbohydrates e.g. xylose, raffinose and salicin.

The pomegranate leaf spot bacterium appears to be a new species of *Xanthomonas* as it is specific in its pathogenicity to pomegranate. It has also shown minor differences in the biochemical reactions from the other related species.

12. Miscellaneous

(a) *Macrophoma leaf-spot of mango*.—The disease has been observed to cause considerable damage to the mango trees in Delhi State. It produces irregular, brown-coloured spots having raised dark purplish margins with dark pycnidial bodies on the necrotic area of the leaf. A species of *Macrophoma* was isolated from the affected leaves which gave positive infection on *Mangifera indica*, *Eugenia jambolana* and *Eriobotrya japonica*, but not on *Psidium guajava*, *Ficus carica*, *Citrus sinensis*, *Musa sapientum*, *Cucumis sativus* and *Nicotiana tabacum* var. *White Burley*.

The pathogen appears to be a new species of *Macrophoma* and has been designated as *M. mangiferae*. It may be briefly described as follows: Pycnidia dark brown, globose, parenchymatous, ostiolate and 77.0–231 μ in size; ostiole measuring 7–17.5 μ in diameter; pycnosporos hyaline, single-celled, oblong, both ends rounded, vacuolate and 15.0–24.5 $\times$ 5.25–7.0 μ in size. The spots are mainly produced on leaves, rarely on young stems, but never on fruits.

It produces very few mature pycnidia on oat-meal agar and Brown's medium after about 40 days of growth. Carbon sources seem to help slightly in sporulation, but not nitrogen sources and vitamins. The maximum effect is, however, obtained when the fungus is exposed to ultra-violet irradiation. Single-spore cultures from the exposed plates have yielded a mutant strain which is stable and differs from the parent culture in having smaller spores (up to 21 μ) and in its ability to form mature pycnidia in abundance within 7 to 10 days.

(b) *Comparative studies on Sclerotium rolfsii* Sacc. and *Ozonium texanum* Neal and Wester var. *parasiticum* Thirumalachar.—Detailed morphological studies indicated that *Sclerotium rolfsii* and *Ozonium texanum* var. *parasiticum* were two distinct entities. Physiological studies showed that nutritional and temperature requirements of the two fungi were similar both for growth and sclerotial formation and that sudden rise or fall in temperature was helpful for sclerotial formation. Both the fungi could grow well on natural media over a wide pH range, while on synthetic media the growth was very poor and no sclerotial formation took place. One peculiar feature of their growth was that, unlike most other fungi, these did not readily utilise carbohydrates. Host-range studies revealed that they attacked all the 20 different plant species tested, showing thereby that there was no host specificity. It was further observed that chemically pure oxalic acid produced the same type of injury as caused by the two fungi, proving thereby that oxalic acid, which is freely produced by the two fungi, was the toxic principle involved.

The sclerotial material of the two fungi placed in the laboratory as well as that kept in the open for 8 months showed 90–96 per cent germination, while that buried

in soil at a depth of 5-7 cm. had 50-65 per cent and the lot buried 10-12 cm. deep had 25-40 per cent germination. Sclerotia immersed in water for 72 hours or exposed to ammonia vapours lost their viability. On the basis of these results, certain control measures e.g. flooding, use of ammonium fertilizers and deep ploughing for the burial of sclerotia have been suggested.

B.—Section of Plant Viruses

13. Tomato

(a) *Leaf curl*.—Different varieties of tomato and five wild species of *Lycopersicon* were tested for their resistance to the disease both by grafting and through viruliferous white-flies with a view to select suitable breeding material. All the thirty-three tomato varieties tested have been found to be susceptible. The percentage of infection in *Lycopersicon peruvianum*, *L. pimpinellifolium*, *L. pississi*, *L. glandulosum* and *L. hirsutum* through insect agency was 4.2, 87.5, 38.5, 55.6 and 16.7, respectively, and in the first four *Lycopersicon* species was 27.3, 66.7, 50.0 and 45.5, respectively, by grafting. *L. peruvianum* has given low infection in the tests so far conducted.

(b) *Necrosis*.—In addition to tobacco, tomato, chilli and *Datura stramonium*, the disease was transmitted to *Nicotiana glutinosa* by grafting. *Aphis gossypii* and *Myzus persicae* failed to transmit the virus.

14. Bhindi

Yellow-vein mosaic.—Investigations on the disease with a view to select resistant varieties and to find out suitable breeding material for evolving resistant types were continued. The disease was transmitted to *Althea rosea*, *Abelmoschus tuberculatus* and *A. ficulneus* both by grafting as well as with *Bemisia tabaci* but not to *Abelmoschus manihot* var. *pangens*, *Hibiscus vitifolia*, *Abutilon indicum* and *Physalis peruviana*. Search for alternate hosts of the virus in the natural flora was in progress.

15. Chilli

Mosaic.—It was confirmed that *Aphis gossypii* acts as the vector for the virus. The virus lost its infectivity when exposed to 60°C for 10 minutes and diluted to 1:30,000. It remained active after 22 days of storage at room temperature (28.5-33°C) and when exposed to ultra-violet irradiation for 4 hours (347.72 m.u.d.) but was rendered innocuous after an exposure of 6 hours to ultra-violet light (514.08 m.u.d.).

16. Brinjal

Mosaic.—The virus was rendered innocuous by freezing the infected leaf tissue for four days. In the varietal resistance tests, 8 varieties of brinjal (Okhla I.C. 488, I.C. 1417, I.C. 514, I.C. 789, *Hyderpur local*, *Surti Gota*, *Majri Gota*, and *American Purple Long*) were found to be susceptible. In the tests conducted so far, *Nicotiana tabacum* var. *turkish*, *N. tabacum* var. *White Burley*, *N. rustica*, *Capsicum frutescens*, *Physalis peruviana*, *Solanum nigrum*, *S. nodiflorum*, *Datura innoxia* and *Lycopersicon esculentum* have indicated susceptibility to the virus, whereas *Phaseolus vulgaris*, *Vigna sinensis*, *Crotalaria juncea*, *Dolichos lablab*, and *Cyamopsis tetragonoloba* did

not take infection. Transmission tests with *Aphis gossypii*, *Empoasca devastans*, Pentatomid bug and grass-hoppers gave negative results.

Previous results of transmission of Delhi strain of the virus with *Empoasca devastans* could not be confirmed in repeated tests.

17. Sesamum

Phyllody.—Studies on the selection of resistant varieties and suitable material for evolving resistant types were continued. Nine more varieties of sesamum (N.P. 3, N. P. 6, N. P. 16, N. P. 18 and Selections, J, K, M, R and Z) were tested under glass-house conditions for their resistance to the disease by grafting, bringing the total number of varieties tested so far to 22. All these varieties have, however, been found to be susceptible. Insect transmission tests with *Eutettix phycitis* gave negative results.

18. Pumpkin

Yellow-vein mosaic.—Studies on the host-range of the virus were continued through the agency of viruliferous white-flies. The disease could be transmitted only to *Lagenaria siceraria*. Inoculations on *Phaseolus vulgaris*, *Medicago sativa*, *Abutilon indicum*, *Abelmoschus esculentus*, *Capsicum frutescens*, *Eclipta alba*, *Cosmos* sp., *Corchorus trilocularis*, *Impatiens balsamina*, *Beta vulgaris*, *Daucus carota*, *Brassica oleracea* var. *capitata*, *B. oleracea* var. *botrytis*, *B. caulorapa* and *Raphanus sativus* gave negative results.

19. Papaya

(a) *Mosaic*.—Papaya mosaic is assuming serious proportions and intensive study of the disease has been taken up. Thirteen plant species were tested to study the host-range of the virus, but with negative results. Search conducted for natural occurrence of the virus in Cucurbitaceous plant species, many of which had earlier been shown to be susceptible to the virus, was unsuccessful.

(b) *Leaf curl*.—The disease is very common in Delhi State and is characterised by curling, puckering and smalling of the leaves accompanied by severe distortion and vein-thickening. The virus was successfully transmitted to papaya by grafting and through viruliferous white-flies.

20. Cotton

"Small-leaf" disease.—Testing of popular commercial varieties of cotton for resistance to the disease by transmission of the virus through grafting were continued. Three varieties, viz., RK 4440, RK 4016 and R 22, were found susceptible, whereas the American L.S.S. cotton proved resistant. The insect-vector of the virus has not so far been established.

21. Banana

Mosaic.—Transmission tests were made by inoculation of infective sap in the presence of an abrasive and also by pin-punctures through diseased leaves on banana, *Cucumis sativus* and *Nicotiana glutinosa*. Only *Cucumis sativus* was successfully

infected and showed vein-clearing of inoculated leaves followed by systemic infection. Banana and *N. glutinosa* did not develop any disease symptoms.

22. Maize

Mosaic.—The virus was successfully transmitted by sap inoculation to maize, jowar (*Sorghum vulgare*), *Sorghum sudanense*, *Euchlaena mexicana*, *Dactyloctenium aegyptiacum* and *Coix lachryma-jobi*. Inoculations on bajra, wheat, barley, sugarcane, *Saccharum arundinaceum*, *Sorghum halepense*, *Pennisetum-orientale*, *P. purpureum*, *Imperata cylindrica* and *Eragrostis curvula* were unsuccessful. The virus could not be transmitted to any of the 25 plant species belonging to *Solanaceae*, *Cucurbitaceae*, *Umbelliferae* and *Leguminosae*. The virus is inactivated by 10 minutes' exposure to 50-55°C and withstands dilution upto 1 : 50 but not 1 : 100. It remains infective after storage for 16 hours at room temperature (28-31°C).

Transmission of the virus by three species of aphids, viz., *Aphis maidis*, *A. gossypii* and *Myzus persicae*, was confirmed and, on an average, 7.3, 19.8 and 24.3 per cent infection, respectively, was obtained.

23. Cardamom

"Katte" disease.—A species of *Amomum*, which grows wild in North Kanara along water channels and moist hill slopes, was found infested with the aphid, *Pentalonia nigronervosa*, and also showed mosaic symptoms similar to the "Katte" disease of cardamom. The mosaic virus from diseased *Amomum* plants was successfully transmitted to healthy plants of the same species as well as to cardamom by means of the aphid vector. The virus responsible for the "Katte" disease was also successfully transmitted to healthy plants of *Amomum* sp. Thus it has been shown that the *Amomum* sp. acts as collateral host of the "Katte" virus. Spraying with 5 per cent Fernoxone has been found effective in destroying the plants of *Amomum* sp.

24. Radish

Mosaic.—The disease was transmitted to *Brassica campestris* var. *sarson*, *B. campestris* var. *toria*, *B. rapa*, *B. nigra*, *B. juncea* and *B. alba* by juice inoculation. The virus was found to be carried symptomlessly in the inoculated leaves of *Brassica oleracea*, *B. oleracea* var. *botrytis* and *B. oleracea* var. *capitata*. The virus is inactivated by 10 minutes' exposure to 90°C and withstands dilution upto 1 : 100,000. It remains infective after storage of 17-19 days at 17-22°C and 101 days at 6-8°C.

Exposure of *Brassica juncea* to ultra-violet irradiation half an hour as also one week after inoculation with radish mosaic virus appreciably inhibited the virus multiplication, while exposure of the host plant before inoculation did not have any effect. Metabolic products of *Trichothecium roseum*, *Aspergillus niger*, *Fusarium avenaceum*, *Rhizoctonia solani*, *Helminthosporium halodes*, *Colletotrichum lindemuthianum* and *Bacillus subtilis* as also extracts of chilli leaves inhibited the virus multiplication.

25. Sarson

Mosaic.—A severe mosaic disease causing considerable loss to the *sarson* crop was observed in Simla area. The diseased plants are greatly stunted and result in a

considerable loss of yield. The virus was transmitted by sap inoculation to *Brassica campestris* var. *sarson*, *B. campestris* var. *toria*, *B. nigra*, *B. rapa*, *B. juncea* and *Raphanus sativus*. Studies on the physical properties and insect-vector relationship of the virus were in progress.

26. Development of new strains, serological relationship and cross-immunity studies

Comparative studies relating to host-range and physical properties of *Cucumis* virus 2C and the mutant strain isolated from it did not show any appreciable differences. The mutant is, however, more virulent than the type virus.

Cross-immunity tests between *Dolichos* enation mosaic virus and the common tobacco mosaic virus conducted on tobacco variety *White Burley*, using "half-leaf inoculation" technique, showed that either of the two viruses could establish and multiply in the presence of the other virus, indicating thereby that there was no antagonism between the two viruses. Also that the tobacco mosaic virus did not protect tobacco plants against reinfection with *Dolichos* enation mosaic virus even when inoculated after 49 days of inoculation with the tobacco mosaic virus. Similar studies with *Datura metel* mosaic virus and the common tobacco mosaic virus conducted on *Datura stramonium* showed that infection of *D. metel* virus did not protect *Datura* plants against reinfection with tobacco mosaic virus.

Investigations on the identification of virus strains involved in eight cultures of the tobacco mosaic virus were continued. Two cultures were identified as typical strains of the common tobacco mosaic virus (*Nicotiana* virus 1) of which one proved to be a very severe strain producing large leafy enations on the underside of tobacco leaves; two cultures (including the one isolated from tomato) showed mixed infection of *Nicotiana* virus 1 and some other virus which was separated through differential hosts; and the remaining four cultures did not show the presence of *Nicotiana* virus 1. The virus cultures other than the typical strains of *Nicotiana* virus 1 are under study.

27. Isolation and purification of plant viruses and study of their properties

The virus causing *brinjal* mosaic was purified by precipitating the virus with ammonium sulphate after removal of extraneous material. The purified virus shows anisotropy of flow when shaken between crossed polaroids, indicating that the virus is composed of rod-shaped particles. The infectivity of the purified material is being tested.

28. Virus-vector relationship

It has been found that white-fly is capable of carrying two different viruses (yellow-vein mosaic viruses of pumpkin and *bhindi*) simultaneously. In the case of yellow-vein mosaic of pumpkin, the results so far obtained indicate that incubation period of the virus in the white-fly, when tested singly or in groups of 20, is about 9 hours. No difference in incubation period was observed in male or female insects. It was further found that the white-fly retains the virus for its whole life after once acquiring it. In the case of "little-leaf" disease of *brinjal*, the incubation period of the virus in its vector, *Eutettix phycitis*, was found to be between 10 and 12 days.

29. Control of virus diseases

The work of controlling "Katte" disease of cardamom by eradication of diseased plants and rehabilitating the gardens by transplanting disease-free seedlings was extended to additional 140 acres, thus bringing the total area under operation to about 950 acres. The disease has been effectively controlled by careful roguing in the experimental area, the disease incidence having been reduced to 0.07 per cent in the extension area.

Spraying the tomato crop with "Ekatox", a proprietary parathion insecticide, was found to give effective control of leaf curl disease under Poona conditions.

30. General

The virus nature of phyllody disease of *Brassica campestris* var. *toria*, *B. campestris* var. *sarson* and *B. rapa* was established. A severe virus disease affecting *Datura metel* in Simla was under investigation. The virus was successfully transmitted by sap inoculation to *Datura metel*, *D. stramonium*, *D. alba*, *Nicotiana tabacum* var. *White Burley*, *N. grandiflora* and *Lycopersicon esculentum*, but not to *Nicotiana glutinosa* and *N. rustica*. *Physalis peruviana* has been shown to be a new host for tobacco leaf curl virus (*Nicotiana virus 10*). Work on mosaic diseases of sugarcane and groundnut and mango malformation was in progress.

31. Taxonomy

Studies on the genera *Cercospora*, *Colletotrichum*, *Phoma* and *Tretopileus* were continued. A number of new hosts, hitherto unrecorded from India, were established. Critical studies on Miscellaneous Indian Fungi were continued and the following fungi of interest were recorded: *Sphacelotheca panjabensis* on *Cenchrus ciliaris*; *Ustilago lorentziana* on *Hordeum stenostachya*; *Tilletia striiformis* on *Poa annua*; *Mycosphaerella* sp. on *Phaseolus mungo*; *Glomerella* sp. on *Mangifera indica*; *Sclerotinia sclerotiorum* on *Cheiranthus cheiri*; *Stachybotrys* sp. on *Saccharum officinarum*; *Marsonia* sp. on *Artocarpus heterophyllus*; *Puccinia hydrocotyles* on *Hydrocotyle javanica*; *Frommea* sp. on *Geranium nepalense*; *Sphaeropsis* sp. on *Citrus* sp.; *Stagnospora* spp. on *Punica granatum*, *Mangifera indica* and *Malus sylvestris*; *Septoria* spp. on *Dolichos lablab*, *Poa* sp. and *Launea asplenifolia*; *Helminthosporium* spp. on *Lolium temulentum*, *L. perrene*, *Typha angustifolia*, *Dactyloctenium aegyptium*, *Pennisetum purpureum* and *Zingiber officinale*; *Alternaria tenuis* on *Lawsonia alba*. Of these fungi, 7 are new species and 14 new host records.

32. Indian Type Culture Collection

Maintenance of the Indian Type Culture Collection, which continued to be a member of the International Federation of Culture Collections linked with UNESCO, was attended to and more than 5,000 subcultures of fungi and bacteria on different media were made in this connection. Twenty-five cultures of fungi and bacteria were added to the Collection, thus bringing the total number of cultures in stock to 945. About 75 fungal and bacterial cultures were supplied to various institutes and research workers in the country and abroad.

Paddy straw mushroom (*Volvaria diplasia*) has been successfully cultivated on paddy straw from the spawn when saturated humidity and temperature of 32-36°C

were provided. Studies on control of preservation of fungal cultures were in progress.

33. Herbarium Cryptogamae Indiae Orientalis

Three hundred and thirteen mycological specimens, which included a large number of Type species of fungi described by various workers in the country, 74 specimens of *Aspergillus* fungi and one specimen each (*Monascus* sp., *Penicillium* sp., *Paecilomyces* sp.) were added to the Herbarium, bringing the total number of specimens to 25,646. One hundred and thirty-four specimens were supplied to various scientific institutions and research workers in the country and abroad. A number of mycological specimens collected locally and received from different sources, were identified.

The first annotated set of Indian Fungi (Fascicle No. II) was added to 11 important herbaria in the world which appears to have been well received and has evoked a good response for exchange of specimens. Fascicle II of Indian Fungi was under preparation. "Fungi of India" by Butler and S. S. S. was revised and brought up-to-date.

PROGRAMME OF WORK FOR 1954-55

I. Plant Pathological Investigations

- (a) Studies on cereal smuts and bunts.
- (b) Determination of physiological races of *Ustilago tritici*, *Monographium heli*, *Puccinia graminis* str. *Puccinia indica*, *Puccinia glaucae* and *Colletotrichum falcatum*.
- (c) Studies on races of wheat, barley, ground and wild grasses.
- (d) Green-Ear disease of bajra.
- (e) "Molya" disease of wheat and barley.
- (f) Efficacy of different seed dressing fungicides.
- (g) Assessment of damage due to various crop diseases: entomological studies.
- (h) Testing varieties of crop plants evolved by the Botany Division for their resistance to diseases.
- (i) Diseases of sugarcane — Factors affecting resistance to *C. falcatum* and occurrence of the red rot epidemic: significance of mixed inocula of *C. falcatum* isolates. Evolving of new varieties resistant to red rot and smut in collaboration with Director, Sugarcane Breeding Institute, Coimbatore.
- (j) (i) Studies on nutritional ecology and antibiotic. (ii) Plant tissue culture and (iii) physiology of fungal parasites.
- (k) Bacterial diseases of plants — (i) "Bands" disease of wheat, (ii) leaf spot of pomegranate, (iii) brown rot of guava and (iv) Red stripe disease of sugarcane.

II. Plant Virus Investigations

- (a) Studies on mosaic viruses of bottlegourd, *L. mel.*, *Cucurbita papaya*, banana, *Cucurbita moschata* and maize. Yellow-vein mosaic of pumpkin; *Dalmanella* mosaic; yellow mosaic and sterility disease of *Cajanus cajan*; leaf curl and necrosis in tomato and chilli; "small-leaf" disease of cotton; mango malformation; sesamum and sannhemp phyllody; "Foorkey" disease of larger cardamom.
- (b) Virus-vector relationship of mosaic of *Cucurbita papaya*, pumpkin, brinjal, yellow-vein mosaic of pumpkin, "Little leaf" of brinjal.
- (c) Isolation and purification of plant viruses and study of their properties: inactivation of plant viruses; and development of new strains and cross-protection tests.
- (d) "Katto" disease of cardamom and its control in Bombay.
- (e) Survey of plant virus diseases.

III. Mycological Investigations

- (a) Taxonomic study of new and unidentified collections available in the Herbarium Crypt. Ind. Orient, preparation of exsiccati sets of Indian fungi, list of fungi deposited in the Herbarium and card indices of species of fungi represented in India; identification of fungi and disease specimens and monographic studies on genera *Cercospora*, *Alternaria*, *Phyllosticta* in India; maintenance of Host Index of fungi; addition to and maintenance of the Herbarium. Survey of diseases of plants with which nematodes are associated and vegetable diseases.
- (b) Maintenance of Indian Type Culture Collection of micro-organisms and their history sheets and study of methods of preservation.

REPORT OF THE DIVISION OF AGRICULTURAL ENGINEERING FOR THE YEAR 1953-54.

(Shri R. V. Ramiah.)

The objectives of the Division of Agricultural Engineering at the I.A.R.I. are to improve the indigenous agricultural implements of India, to design new implements and machines, as well as to introduce from abroad such of the farm implements and machinery, which can be adapted to Indian conditions by slight and suitable modifications. Field Testing of tractors, power machinery and pumps for irrigation purposes are also included in the activities of the Divisions. During the year under report, testing and improvement of water lifting appliances, and improvement of agricultural processing machines such as Cotton Gin, Paddy Sheller and Rice Polisher, Oil Ghanis, Decorticators, etc. were also taken up. Extension work, pertaining to the production and popularisation of improved agricultural implements in the States was started as an additional activity of the Division from this year.

GENERAL.

(a) The following machines and implements were received for tests and trials during the year :—

- (1) Buck Scraper from Messrs. P. S. G. & Sons, Coimbatore.
- (2) Three sizes of Bund Formers from Messrs. P. S. G. & Sons, Coimbatore.
- (3) “ Zuiko ” Rubber-Roll Paddy Sheller from Messrs. J. Khushaldas & Co., Bombay. This is a paddy sheller made in Japan.
- (4) “ Bose ” plough from the Assistant Project Officer, Madurai.
- (5) Two sizes of centrifugal pumps from Messrs. Unique Metal Works, Aligarh.
- (6) “ Sona ” tractor from Messrs. Howrah Trading Co. Ltd., Calcutta. This is a tractor assembled in India.
- (7) Improved bullock drawn water lift from Messrs. Lakshmi Engineering Co., Delhi.

(b) Advice on technical matters was given to the Divisions of the Institute concerning selection, purchase and approval of engineering stores. In this connection the following work may be mentioned :—

- (1) Approval of furniture and fitting, etc., made for the Library, Hostel and Central Office.
- (2) Inspection and testing of refrigerators and cooling plants of the Entomology and Mycology Divisions.
- (3) The Division of Agricultural Engineering continued to assist the Division of Agronomy in attending to the repairs and maintenance of all field equipment, owned and operated by them. Advice regarding selection

and purchase of spare parts and agricultural implements and machines was given as usual to the Division of Agronomy and the Agricultural Sub-station at Karnal.

- (4) A portable pumping set operated by a diesel engine was selected and purchased through the Directorate General of Supplies and Disposals for use in the Botanical Sub-station, Pusa. The pumping set was tested at the I.A.R.I. before despatch to Pusa.
- (5) Technical supervision of the Activated Sludge Plant and its maintenance.
- (c) The working drawings of the following agricultural implements and machines were prepared during the year :—
 - (1) Six different types of chaff cutter blades for the Indian Standards Institution for purposes of standardisation.
 - (2) Hand operated all-steel rotary screen.
 - (3) Hand operated rice sheller.
 - (4) Jute seed drill with seed releasing attachment.
 - (5) Groundnut planter with seed-box.
 - (6) Improved Circular Mhote.
 - (7) Japanese type double-row rice-land weeder.

SCHEMES.

(1) A scheme for Production, Demonstration, Trial and Popularisation of Improved Agricultural Implements, financed by the Indian Council of Agricultural Research, was started in this Division from 3rd October 1953. A list of implements considered suitable for popularisation in the States was prepared and circulated to all the States. Some of the States have made selections of the implements that will suit their requirements. The list includes implements that need to be introduced in some parts of India as well as some machines of Japanese origin that are new to India. Under the scheme it is intended to distribute free of cost to all the State Governments such implements that are considered suitable for trials by them in their regions. After consolidating all the demands from the State Governments, an indent has been placed with the Directorate General of Supplies and Disposals. Action for the purchase of these implements has been initiated by the Directorate General of Supplies and Disposals at present.

(2) A set of catalogues on manually operated and horse drawn implements was obtained from the following countries through the Indian Embassies :—

- (1) England.
- (2) France.
- (3) Sweden.
- (4) Austria.
- (5) Italy.
- (6) The U. S. A.
- (7) Japan.
- (8) Canada.

These were required in connection with a recommendation made by the Planning Commission that suitable implements should be obtained for trial and testing from foreign countries for popularisation in India. A detailed scheme, covering this proposal with statements of expenditure involved, has been prepared by this Division and submitted to the Ministry of Food and Agriculture (Agriculture) for their consideration and sanction under the heading "the scheme for import and trial of foreign agricultural implements".

DEMONSTRATION OF TRACTORS AND IMPLEMENTS, ETC.

(1) A demonstration of "Fuji" Japanese tractors was held at the farms of the Indian Agricultural Research Institute by Messrs. Indian Engineering and Commercial Corporation, Lucknow on 22nd May 1954. It was attended by a distinguished gathering including Dr. P. S. Deshmukh, Central Minister for Agriculture, Shri M. V. Krishnappa, Central Deputy Minister for Food, officers of the Institute and other interested persons. The demonstration lasted for about an hour during which the tractor was used on fields for ploughing and puddling and as a prime mover for driving a centrifugal pump, a chaff cutter and a grinding mill. The engine of the tractor was a 5-6 H.P. kerosine operated one.

(2) A field demonstration of an off-set disc harrow, designed and built by Messrs. Escorts Ltd., New Delhi, was given in the Todapur area of the Indian Agricultural Research Institute farms on 27th August 1953. The demonstration was attended by Shri Rameshwar Dayal, Administrator, Faridabad, some officers of the Central Tractor Organisation and engineers of Messrs. Escorts Ltd. The implement was hitched behind a Ferguson tractor, through the hydraulic lift and its performance was found to be better than the ordinary disc harrows, now supplied with the Ferguson tractors. The off-set disc harrow was tried in both the cultivated as well as fallow lands. It gave better quality of seed bed with deeper penetration.

PARTICIPATION IN EXHIBITIONS.

(1) This Division participated in the All India Industrial Exhibition, held at Hyderabad. Improved agricultural implements and machines were sent there for display at the exhibition and demonstration in selected areas of the State. The demonstration and working of the Japanese rubber-roll paddy sheller and rice polisher attracted the interest of the farmers. The Bengal plough for puddling in rice fields proved quite useful as it could be conveniently worked and its output was about 50 per cent more than that of the local plough. The models of the water lifts and the groundnut planter also attracted a good deal of attention from the people.

(2) Implements and machines from this Division were also displayed at the All India Cattle Show held at Bahadurgarh between 23rd March 1954 and 28th March 1954. The following machines and implements proved to be of special interest among the farmers who came to the cattle show from the surrounding villages :—

- (a) The winnowing fan by which the separation of grain can be effected from straw and dust without a natural wind.

- (b) The Olpad thresher which gives a higher output of threshed grain than is ordinarily done by trampling under the feet of bullocks and at the same time produces Bhusa of good quality as cattle feed.
- (c) Bullock drawn reapers for harvesting.
- (d) Wheat seed drill.
- (e) The water lift models.

(3) At the stall of the Khadi and Village Industries Exhibition held at the Ramlila grounds, New Delhi, some implements like, Olpad thresher, winnowing fan, paddy weeders and threshers, hand push carts, wheel barrows, a collection of ploughs, groundnut planter and grain screen were exhibited.

FILM ON AGRICULTURAL IMPLEMENTS.

Facilities were given to the United States Information Service and Messrs. Ama Ltd., Bombay for preparing a film on use of improved agricultural implements.

Improved agricultural implements like soil turning ploughs, seed drills, winnowing fan, reapers, power thresher, Olpad threshers (bullock drawn), combines and water lift models were made available to the party. Their working was demonstrated by workers of this Division to the villagers while the making of the film was in progress. Implements and machines displayed at the All India Cattle Show, Bahadurgarh, were also included in the film.

RESEARCH AND FIELD TRIALS.

(1) *Tests of tractors.*—Field and laboratory tests were conducted on a 'SONA' tractor submitted by Messrs. Howrah Trading Co. Ltd., Calcutta. This tractor was equipped with a trailing type single bottom plough. During the preliminary trials, method of attachment of the plough was found to be defective and hence the single bottom plough could not be worked. Tests of the tractor were conducted by utilising the available draw-bar of an "Allis-chalmers B" tractor with suitable modifications and a Massey Harris single furrow plough of the mould-board type. The tractor was tried in ploughing and discing operations. The following observations were made :—

Ploughing—

Condition of field	Slightly infested with growth of shrubs and weeds.
Depth of ploughing	3½".
Output per hour	0.138 acres.
Fuel consumption per hour	0.363 gallons of diesel oil.
Output per gallon of fuel	0.38 acres.
Slippage of land wheels	2.5 per cent.

Discing—

Depth of discing	1½"—2".
Output per hour	0.33 acres.
Fuel consumption per hour	0.343 gallons.
Output per gallon	0.96 acres.

A few defects in design and construction of the tractor were observed during the course of the trials and suggestions have been made for effecting these improvements. It was considered that the tractor and its implements were not ready for production in the present stage.

(2) *Test of a Pull-Meter (dynamometer).*—A pull-meter (dynamometer) reading upto 10,000 lbs., in steps was supplied to this Division by Messrs. Associated Exports and Imports Corporation, Calcutta. The instrument was tested in the workshop by recording the draw-bar pull of a "Deutz" single cylinder tractor. For conducting this test a "Deutz" two cylinder tractor was pulled by another "Deutz" single cylinder tractor on level ground. The pull-meter was attached between the two tractors. The pull or draft was exerted by operating the pulled tractor in different gears. The pull-meter operated satisfactorily in the beginning of the test but the fluid started leaking from the joint connecting dial to the body after some time. The pull recorder was rendered out of action by a jerk during the course of experiments. It was found that the pull-meter had developed a zero-error of about 750 lbs., and the needle was not coming back to its normal position. The pull-meter was then returned to the firm at their request. There has been some interest in the use of dynamometers for measuring draft of field implements and information is being collected, so that a suitable dynamometer may be selected for this purpose in India.

EXPERIMENTS ON SEED-BED PREPARING IMPLEMENTS.

"*Bose Plough*".—A new type of country plough-share was received from the Assistant Project Officer, Madurai for tests in this Division. The share, which is similar to that of the Japanese plough, was fitted to a country plough bottom available at Delhi and tried in the Institute farm. The performance of the plough was not satisfactory in dry cultivated lands but was found suitable for puddling work with 1 or 2 inches of standing water in the field. The test data are given below :—

Type of land.	Furrow.		Average draft in Lbs.	Remarks.
	Depth.	Width.		
Cultivated land (dry) . . .	3"—3½"	5"	100	Not satisfactory.
Virgin land (dry) . . .	3"—3½"	5"	145	Ditto.
Land with standing water of 1½" depth	6" (approx.)	5" (approx.)	210	Puddling satisfactory.

EXPERIMENTS ON RICE CULTIVATING & PROCESSING IMPLEMENTS AND MACHINES.

(1) *A Rice land puddler.*—With a view to design a cheep puddler for use in rice fields, two sets of attachments of rotating blades were fixed to an available mould-board plough. The attachments were made by welding pieces of mild steel plate of suitable shape and this puddler assembly could be fixed on either side of the mould-board. The rotating blades of the puddler, puddle the field, and the plough is rendered ineffective by being lifted up. The performance of this puddler was compared with a puddler manufactured by Messrs. P. S. G. Industrial Institute, which has three sets of rotating blades mounted on suitable axles in a frame.

The new puddler had to be cleaned from weeds four times during the course of its operation, while the other one only twice. It was observed from these tests that although the new puddler was lighter and cheaper, its performance was comparatively less than the one manufactured by the P. S. G. Industrial Institute.

(2) *Markers for transplanting*.—In order to facilitate transplanting of rice seedlings in rows in fields having standing water of about 1" depth, two types of markers have been built for experimental purposes. One of them is a wooden plank of about 1" thickness and 12'—0" long with wooden pegs fitted on one face at 9" apart. The gap between the pegs can be changed at quick notice to any required spacing of more than 9". While operating, two men are required to press down the ends of planks on loose soil.

Another marker is made of a hollow wooden roller, on the periphery of which the wooden pegs are fixed. These pegs leave impression on the loose earth to transplant the seedlings.

Both the implements were operated in wet soils with standing water. It was found that the impressions left by the pegs were soon filled in by the wet earth and after some time the marks could not be located. Thus, these markers could not be used for transplanting of paddy.

(3) *Japanese paddy shellers*.—(a) The Japanese power-operated rubber-roll paddy sheller, received from the Central Rice Research Institute, Cuttack, was tried in the workshop. It was run by a 2 BHP electric motor at a speed of 1145 RPM. The machine was found satisfactory. The following data was recorded. Graded paddy of New Pusa variety was used and no bran was produced—

Total output of paddy per hour	220 lbs.
Percentage of clean and unbroken rice	70.80
Percentage of husk	25.80
Percentage of unshelled paddy	3.40
Percentage of broken rice	Nil.

The rice shelled by this machine required polishing.

(b) A "Zuiko" power operated paddy sheller, made in Japan, was obtained from Messrs. J. Khushaldas and Co., Bombay for tests and trials :—

Output per hour of paddy	820 lbs.
Percentage of shelled rice	67.50
Percentage of unshelled paddy	1.5
Percentage of husk	31.00
Percentage of broken rice	Nil.

No bran was produced and the shelled rice required polishing.

(4) *Japanese grain screen*.—The Japanese grain screen, which consists of four sieves of different mesh sizes and separates grains from unwanted materials, such as

weeds, chaff, stones, etc., was tried with wheat and paddy. During the trials, it was found that it could screen out 259 lbs. of paddy or 321 lbs. of wheat in an hour i.e., 2,072 lbs. of paddy or 2,568 lbs. of wheat in a day of 8 hours.

(5) *Japanese rice polishing machine*.—The Japanese rice polishing machine, obtained from the Central Rice Research Institute, Cuttack, was tried in this Division. The machine was operated by 2 H.P. electric motor at a speed of 1,400 R.P.M., and was found that it caused almost no breakage of rice when the pressure plate was elevated to a raised position.

It could not produce polished rice from paddy like other Indian or foreign machines (usually called hullers). It was capable of polishing 205 lbs. of shelled rice (or brown rice) per hour. The polishing could, however, be carried out to any desired extent with this machine. Thus the Japanese rice polisher, is only an accessory to a paddy sheller and cannot be used as a huller.

EXPERIMENTS ON WATER LIFTS, ETC.

(1) *Persian Wheels*.—(a) An efficiency test of the persian wheel in use in the Agricultural Farm, Karnal was carried out. The water lift was of the old conventional type, fitted with wooden bearings. The overall efficiency was found to be a little more than the figures obtained in similar experiments conducted in this Institute during 1950.

Distance travelled by bullocks per minute		222 ft.
Depth of water level from ground		17'—3"
Dynamometer pull		122 lbs.
Discharge of water in gallons per minute		72
H. P. input		0.861
H. P. output		0.376
Overall efficiency		46%

(b) Tests of efficiency were carried out on the two water lifts of different designs installed at Panipat. One of the two water lifts was of the conventional type and the other was an improved one, known as Krishnapura water lift. The following observations were made :—

	Krishnapura water lift.	Conventional water lift.
Travel of bullock per minute	165.6 ft.	170 ft.
Height of water level	24 ft.	24 ft.
Average draft	190 lbs.	160 lbs.
Water lifted per hour	4,140 galls.	2,760 galls.
Effective length of beam	13'—2"	13'—2"
Mechanical efficiency	52.1%	44.0%

(c) Field test on the output of Persian wheel was conducted near Gurgaon with experts of the Ford Foundation. The following results were obtained :—

Depth of water from ground level	42'—6"
Output in gallons per hour	2,000 imp. galls.
H. P. output	0.43

The output of Persian wheels when operating at depths of about 43' is 2,000 gallons/hour.

(2) *Charsa*.—Some experiments were conducted on 'Charsa' an indigenous water lift with leather buckets, which is a popular device for irrigation in several parts of India. Two charsas were tried in the village Naraina and following observations made :—

	Charsa No. 1 with one pair of bullocks.	Charsa No. 2 with two pairs of bullocks.
Discharge of water per hour	1,600 galls.	4,800 galls.
Height of water lift	53'—6"	38'—0"
Draft	300 lbs.	320 lbs.
Overall efficiency	49.2%	53.5%

The input of power was calculated on the downward as well as the upward journey of bullocks, while the water was discharged only on the downward journey of bullocks.

(3) *Bullock operated pumps*.—(a) Under the supervision of experts of the Ford Foundation, a bullock drawn plunger pump, supplied by M's. Zamindar Foundry, Batala, was tested. This pump required modifications and improvements in its buckets and in the design of the inlet and outlet valves. Some improvements in design are being effected by the firm.

(b) At the instance of Messrs. Lakshmi Engineering Works, Delhi, a bullock operated water lift, manufactured by them and consisting of two sub-assemblies, namely, a bullock gear and a pumping unit, was put to test in this Division. The draft of the pump, being 340 lbs., was considered to be rather heavy. The efficiency of the pump worked out to be 2.10 per cent at the first trial, but it was possible to increase this to 8.90 per cent with an average output of 2,640 gallons per hour from a depth of 12'—8" after carrying out certain modifications. As this result was also not satisfactory, the firm is now contemplating further improvement on the machine, which will be tried again at a later stage.

(4) *Circular Mhote*.—A few experiments were carried out previously with an improvised model of the Circular Mhote, used in the ceded districts of Madras State and some test data were presented in the last annual report of this Division. In continuation of those experiments, an actual working model of the Mhote was erected near a well in the I.A.R.I. farms this year and fitted with differential pulleys, alternately in the vertical and horizontal plane. The results obtained in these

trials are summarised below. The turning radius of 10' - 6" and the weight of 200 lbs. of water lifted per round, remained constant in all cases.

(i) With differential pulley working on the vertical plane.

Height of water level.	Draft.	Efficiency.
20 ft.	190 lbs.	33.49%
24 ft.	220 „	32.20%
28 ft.	250 „	33.94%

(ii) With differential pulley on the horizontal plane sliding on angle iron rails through rollers.

Height of water level.	Draft.	Efficiency.
21 ft.	215 lbs.	29.60%
24 ft.	250 „	29.80%
27 ft.	280 „	29.22%

It is evident from the above data, that the efficiency of water lift decreases when the differential pulleys are used on the horizontal plane. Moreover, this arrangement, though convenient, is comparatively expensive. The method of using the differential pulleys on the vertical plane, is of course better as far as efficiency and cost are concerned but there is the practical difficulty of fixing the end of the rope near the water level in the well.

Experiments will be conducted to find out the proper location of the pulleys.

HAND OPERATED COTTON GIN.

At the instance of Dr. P. S. Deshmukh, Minister for Agriculture, Government of India the work of improvement of a small size cotton gin was undertaken. A hand-cum-power operated cotton gin was secured from the Cotton Technological Laboratory of the Indian Central Cotton Committee, Bombay. With a view to reducing the cost of construction, a model of the hand operated cotton gin was fabricated in wooden parts (with a few steel parts only) and was tested. The output of this gin was not more than the indigenous one of the same size. Hence the model of the I.C.C.C. was of no advantage.

Some improvements were made in the indigenous cotton gin by fitting the two rollers with two cast iron gear wheels at one end for driving and by providing four brass bearings, two for each roller at both the ends. This machine with the improvements as mentioned above is more durable and easier in operation than the indigenous one. There is practically no difference in the output of the two machines.

The costs of operation per maund of lint cotton by the indigenous cotton gin (hand operated) or the improved one, were found to be more than that of a mechanical cotton gin used in large size establishments. Thus, the use of the indigenous cotton gin or its improved model is limited for cottage use for separating cotton seeds from the lint.

MISCELLANEOUS EXPERIMENTS.

(1) *Test of improved ghani.*—Under the auspices of the Indian Central Oil Seeds Committee, a trial and demonstration of improved bullock drawn ghanis was held in Hyderabad to determine the best model and to award a prize of Rs. 5,000. Three working models were available for trials and the Wardha Ghani, the test results of which are given below, was awarded the prize :—

Rate of crushed seeds per hour (til seeds)		21.98 lbs.
Percentage of extraction of oil by weight.		41.64
Draft (single bullock)		102 lbs.

(2) *Test of improved Mowha seed decorticator.*—Trials of Mowha seed decorticators were held at the instance of Indian Central Oil Seeds Committee in this Division to find out the best model for an award of Rs. 2,000. Four decorticators were tested. The results of tests have to be considered by a sub-committee of the Indian Central Oil Seeds Committee.

INTENSIVE CULTIVATION.

(a) The following implements were demonstrated under Intensive Cultivation Scheme in the villages near Delhi :—

- (1) Bhakhars or blade harrows.
- (2) Japanese rice land weeders.
- (3) Japanese pedal thresher for paddy
- (4) Double plough.
- (5) Olpad threshers.

(b) About 125 acres of fallow land in the village of Nilothi, under the Intensive Cultivation Scheme undertaken by the I.A.R.I., were ploughed by a D4 Caterpillar tractor and 3 furrow mould-board plough. The land had been infested with grass, as it had gone out of cultivation for want of bullock power in the villages.

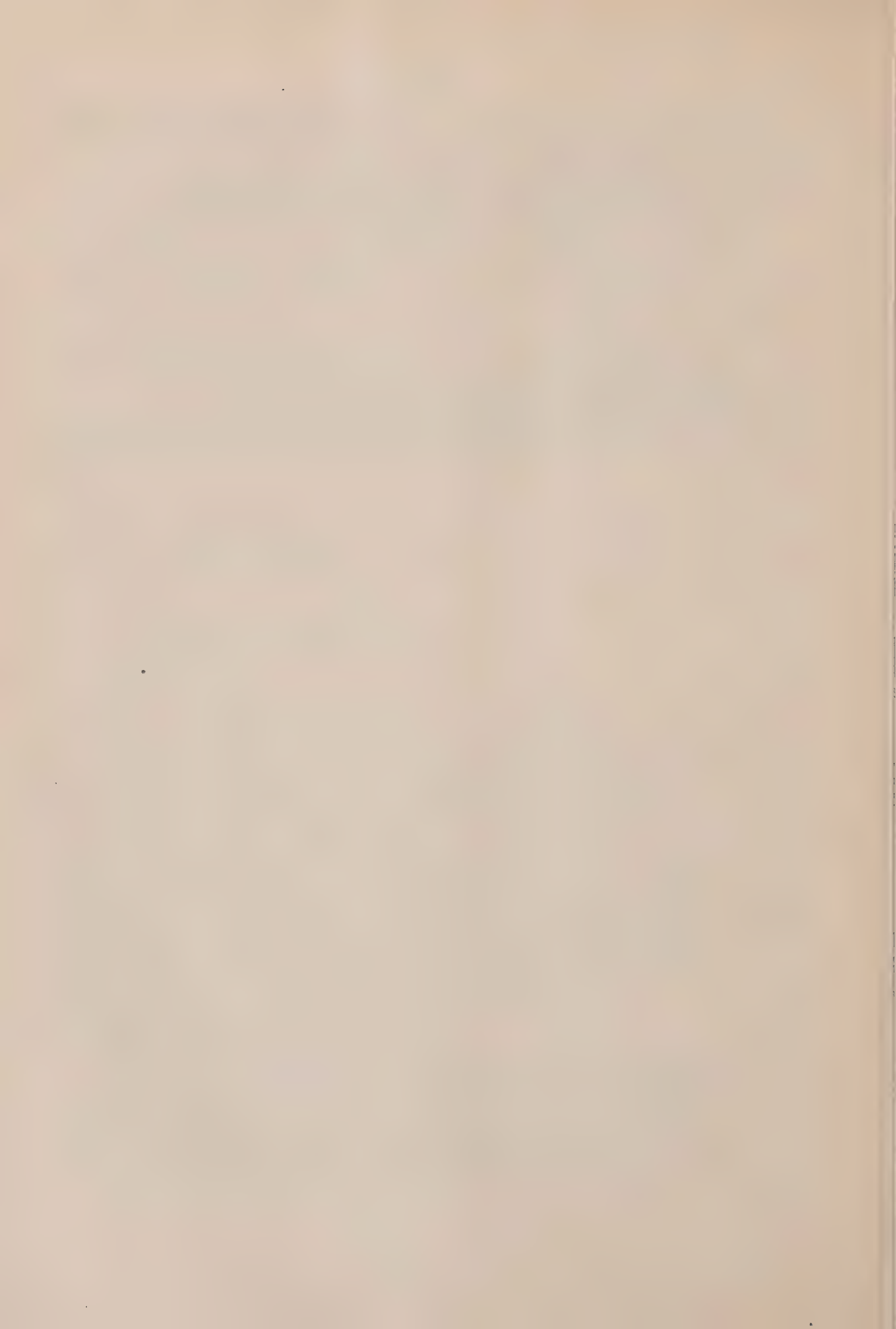
(c) Demonstrations on threshing wheat by a tractor and disc-harrow, as well as by using bullock drawn "Olpad" threshers were given in the villages of Qamaruddin Nagar, Nilothi, Nangloi, etc. The main advantage of this method is that it produces good quality "Bhusa" for animal feed and does not damage the wheat grains. It is also economical in cost. The villagers have purchased Olpad thresher for their own use. The demonstrations were very popular with the villagers.

(d) A comprehensive note for the introduction of improved agricultural implements in the village of Qamaruddin Nagar was prepared.

PROGRAMME OF WORK FOR 1954-55.

1. Continuation of the I.C.A.R. Scheme for production, demonstration, trial and popularisation of Improved Agricultural Implements.
2. Starting of a scheme for opening a museum of agricultural implements at the I.A.R.I.
3. Improvement of the Madras Mhote or single bullock water lift for increasing its total lift.

4. A study of the ' Charsa ' and its trial and demonstration for automatic unloading of water.
5. Testing of centrifugal pumps for efficiency and performance.
6. Continued experiments on winnowing fans and grain cleaners.
7. Design and construction of bullock drawn implements for placement of chemical fertiliser.
8. Study of sprayers, dusters, etc., and construction of a bullock drawn sprayer for row crops.
9. Import and trial of threshing machines for wheat and oats from Japan and Portugal.
10. Experiments on using tractors for rice land cultivation.
11. Testing of bullock operated pumps.
12. Any other projects to be suggested by the Ministry of Food and Agriculture.



PART III—APPENDICES

Appendix I

Gazetted staff of the Indian Agricultural Research Institute during 1953-54.

1. Director Dr. B. P. Pal, M.Sc., Ph.D. (Cantab), F.L.S., F.N.I., F.B.S.
2. Personal Assistant to the Director. Shri J. M. Banerjee, M.A.
3. Librarian (Class II non-gazetted) Shri N. N. Chatterjee, B.Sc., Diploma in Librarianship Diploma in French, German and Russian.

DIVISION OF AGRONOMY

1. Head of the Division and Principal, Central College of Agriculture. Dr. T. J. Mirchandani, M.Sc., Ph. D., A.I.I.Sc. (London).
2. Agronomist Shri S. Sen, M.Sc.
3. Ditto Shri J. J. Chandnani, M.Sc. (Ag.) (officiating *vice* Dr. P. C. Raheja with effect from 29-4-1953).
4. Ditto Shri A. R. Khan, B.Sc. (Ag.), M.Sc. (Wiscon). (Officiating *vice* Dr. N. P. Datta with effect from 29-4-1953).
5. Assistant Agronomist . . F/Lt. R. D. Verma, B.Sc. (Ag.), B.Sc. (Hons.) (Edin). (On leave out of India).
6. Ditto Shri Sher Singh, B.Sc. (Ag.), (Officiating *vice* Shri A. R. Khan with effect from 16-2-1954).
7. Ditto Shri K. P. Misra, M.Sc. (Ag.), (Officiating *vice* Shri J. J. Chandnani with effect from 16-2-1954).
8. Assistant Agrostologist . . Shri P. M. Dabadghao, M.Sc. (On deputation with the Indian Council of Agricultural Research).
9. Assistant Statistician . . Dr. P. N. Saxena, M.A., Ph.D.
10. Assistant Agronomist (Scheme for agronomic trials with T. C. A. fertilizers). Dr. K. S. Yawalkar, B.Sc., Ph.D., Assoc. I.A.R.I. (From 16-2-1954).

DIVISION OF BOTANY

1. Head of the Division . . . Dr. R. D. Asana, M.Sc., Ph.D., D.I.C. (Officiating till 17-5-1954).
Dr. S. M. Sikka, M.Sc., Ph.D. (From 18-5-1954).
2. Plant Physiologist . . . Dr. R. D. Asana, M.Sc., Ph.D., D.I.C. (Reverted to the post on 18-5-1954).
Shri T. J. Malkani, M.Sc. (Officiating from 18-2-1953 to 17-5-1954).
3. Geneticist Shri R. B. Deshpande, M.Ag., Assoc., I.A.R.I. (On leave preparatory to retirement with effect from 20-4-1954).
Dr. A. B. Joshi, M.Sc., Ph.D., Assoc. I.A.R.I. (Officiating with effect from 21-4-1954).
4. Cytogeneticist . . . Dr. P. N. Bhadhuri, Ph.D.
5. Systematic Botanist . . . Dr. D. Chatterjee, M.Sc., Ph.D. (Lond.).

6. Wheat Breeder (Co-ordinated Wheat Rust Control Scheme). Dr. G. S. Murti, M.Sc., Ph.D., Assoc. I.A.R.I.
7. Assistant Botanist (Plant Introduction Scheme). Shri H. B. Singh, M.Sc., Assoc. I.A.R.I. (Temporary up to 7-7-1953).
8. Assistant Geneticist . . . Shri H. B. Singh, M.Sc., Assoc. I.A.R.I. (From 8-7-1953).
9. Assistant Cytogeneticist . . . Dr. A. B. Joshi, M.Sc., Ph.D., Assoc. I.A.R.I. (Up to 20-4-1954.) (The post has since remained vacant).
10. Assistant Plant Physiologist . . . Shri V. S. Mani, M.Sc. (From 18-2-1953 to 17-5-1954).
Shri T. J. Malkani, M.Sc. (Reverted from 18-5-1954).
11. Assistant Wheat Breeder (C.W. R.C.S.). Shri S. Sen, M.Sc.
12. Assistant Economic Botanist (Maize Breeding Scheme). Dr. N. L. Dhawan, M.Sc., Ph.D., Assoc. I.A.R.I. (From 24-6-1953 to 10-2-1954).
13. Assistant Geneticist . . . Dr. N. L. Dhawan, M.Sc., Ph.D. (From 11-2-1954).
14. Assistant Cytogeneticist (Scheme for cytological studies on oilseeds). Shri S. S. Rajan, M.Sc.
15. Superintendent of Gardens (Horticultural Section). Shri Ramesh Chandra, B.Sc. (Ag.). (From 24-4-1954).

DIVISION OF AGRICULTURAL CHEMISTRY AND SOIL SCIENCE

1. Head of the Division . . . Dr. S. P. Raychaudhuri, M.Sc., Ph.D. (Lond.), D.Sc. (Cal. & Lond.), F.R.I.C.
2. Soil Microbiologist . . . Dr. N. D. Vyas, M.Sc., Ph.D. (Officiating up to 24-1-1954).
Dr. S. V. Desai, B.Sc., Ph.D., D.Sc., D.I.C. (Came back from deputation to Rajasthan Government Service and joined duties on 25-1-1954 and retired on 5-3-1954). (The post is at present lying vacant).
3. Soil Survey Officer . . . Dr. R. V. Tamhane, B.Ag., Ph.D. (Lond.).
4. Biochemist . . . Dr. N. B. Das, M.Sc., Ph.D.
5. Organic Chemist . . . Dr. K. C. Gulati, B.Sc. (Hons. Tech.), M.Sc. (Hons.), Ph.D. (Left on other duties in the Ministry of Commerce & Industry on 14-7-1954).
6. Fertilizer Technologist . . . Shri M. A. Idnani, B.Sc., Assoc. I.A.R.I. (Temporary up to 17-2-1954).
Dr. C. N. Acharya, M.Sc., Ph.D., D.Sc. (Lond.), F.R.I.C., (from 18-2-1954).
7. Experimental Physicist . . . Dr. C. Dakshinamurti, M.Sc., Ph.D. (Lond.), D.Sc. (Banaras).
8. Soil Scientist (T. C. A. Scheme for determination of soil fertility and fertilizer use). Dr. N. P. Datta, M.Sc., D.Sc. (From 12-11-1953 forenoon).
9. Agronomist (T. C. A. Scheme for determination of soil fertility and fertilizer use). Dr. P. C. Raheja, M.Sc., Ph.D. (From 9-11-1953 afternoon).
10. Statistician (T. C. A. Scheme for determination of soil fertility and fertilizer use), (Junior Class I) Shri T. P. Abraham.
11. Assistant Agricultural Chemist Shri A. B. Ghosh, M.Sc. (From 16-7-1953 to 17-2-1954).
Shri M. A. Idnani, B.Sc., Assoc. I.A.R.I. (Reverted on 18-2-1954).
12. Assistant Soil Microbiologist . . . Dr. N. D. Vyas, M.Sc., Ph.D. (On leave with effect from 24-1-1954 for 4 months and retired on 23-5-1954).
Dr. A. Sen, M.Sc., Ph.D., Assoc. I.A.R.I. (From 20-3-1953).
13. Assistant Soil Physicist . . . Dr. B. T. Mulwani, B.Ag., M.Sc., Ph.D. (Lond.), D.I.C.
14. Assistant Soil Survey Officer . . . Dr. K. V. S. Satyanarayana, B.Sc. (Ag.), Ph.D., Assoc. I.A.R.I.
15. Ditto . . . Shri L. M. Mathur, M.A., B.T., A.S.T. (On deputation).

16. Assistant Physical Chemist . . . Dr. B. Ramamurti, M.Sc., Ph.D., A.R.I. (Lond.), Assoc. I.A.R.I. (Officiating *vice* Dr. B. B. Roy on other duty since 6-11-1952).
17. Assistant Organic Chemist . . . Dr. A. C. Bose, B.Sc. (Hons.), Ph.D. (Lond.), A.I.C. (Lond.). (Services terminated on 22-9-1953).
18. Assistant Soil Chemist . . . Dr. B. V. Subbiah, M.Sc., Ph.D. (From 22-5-1953).
19. Ditto . . . Shri A. B. Ghosh, M.Sc. (Officiating *vice* Dr. C. N. Acharya from 18-2-1954).

DIVISION OF ENTOMOLOGY

1. Head of the Division . . . Dr. E. S. Narayanan, M.A., Ph.D. (Lond.), D.I.C., F.R.E.S., F.E.S.I.
2. Systematic Entomologist . . . Dr. S. Mukherji, M.Sc., D.Sc.
3. Insect Ecologist . . . Dr. S. Pradhan, B.Sc. (Hons.), M.Sc., Ph.D. (Lond.), D.Sc., F.R.E.S., F.E.S.I.
4. Assistant Systematic Entomologist. Shri C. K. Samuel, B.Sc., Assoc. I.A.R.I.
5. Assistant Insect Epidemeologist Shri T. V. Venkatraman (officiating) (on duties under the South Pacific Commission with effect from 11-2-1954).
6. Assistant Entomologist . . . Shri S. M. Chatterji, M.Sc. (From 5-9-1953).
7. Assistant Insect Physiologist . . Dr. Rattan Lal, M.Sc., Ph.D. (On deputation).

DIVISION OF MYCOLOGY

1. Head of the Division . . . Dr. R. S. Vasudeva, D.Sc. (Lond.), Ph.D. (Lond.), D.I.C., F.N.I.
2. Systematic Mycologist . . . Dr. B. L. Chona, B.Sc., Ph.D. (Lond.), D.I.C. (Lond.).
3. Mycologist (C.W.R.C.S.) . . . Dr. R. Prasada, M.Sc., D.Sc. (Agra).
4. Assistant Plant Pathologist . . . Dr. M. R. S. Iyenger, M.Sc., Ph.D. (Officiating from 1-4-1954 *vice* Dr. R. Prasada on other duty).
5. Ditto . . . Dr. M. L. Gattani, M.Sc., Ph.D. (Minn.).
6. Assistant Virologist . . . Dr. S. P. Raychaudhuri, M.Sc., D.Phil. (Càl.), F.L.S., Assoc. I.A.R.I.
7. Assistant Plant Bacteriologist . . Dr. M. K. Hingorani, B.Sc. (Ag.), Ph.D. (Minn.), Assoc. I.A.R.I.

DIVISION OF AGRICULTURAL ENGINEERING

1. Head of the Division . . . Shri R. V. Ramiah, B.E. (Mech), M.Sc. (A.E., Iowa), M.A. S.A.E.
2. Assistant Engineer . . . Shri J. S. Manku, B.Sc. (Elect. & Mech. Engg.), A.M.I.E., A.I.M.E.
3. Ditto . . . Shri Ram Pratap Singh, B.Sc. (Agricultural Engineering), M.Sc. (Agric.). (From 25-11-1953).

AGRICULTURAL RESEARCH SUB-STATION, KARNAL

1. Assistant Agronomist . . . Shri B. D. Ganguly, B.Sc. (Ag.).

BOTANICAL SUB-STATION, PUSA (BIHAR)

1. Superintendent . . . Shri M. D. Nandkeolyar, M.Sc.

CO-ORDINATED WHEAT RUST CONTROL SCHEME

(a) Simla Centre—

1. Assistant Wheat Breeder . . . Dr. S. P. Kohli, M.Sc., Ph.D.
2. Assistant Mycologist . . . Shri V. C. Lele, M.Sc.
3. Ditto . . . Shri R. L. Munjal, M.Sc. (From 7-8-1953).

(b) Indore Centre—

1. Assistant Wheat Breeder . . . Shri V. S. Mathur, M.Sc.

(c) Wellington Centre—

1. Assistant Wheat Breeder . . . Shri V. K. Srinivasan, M.Sc.
2. Assistant Mycologist . . . Shri L. M. Joshi, M.Sc. (From 7-8-1953).

(d) Pusa Centre—

1. Assistant Wheat Breeder . . . Shri S. Kedhar Nath, M.Sc.

CO-ORDINATED PLANT VIRUS RESEARCH SCHEME

(a) Poona Centre—

1. Virus Entomologist . . . Shri L. M. Verma, M.Sc.
2. Virus Pathologist . . . Dr. S. P. Kapur, M.Sc., Ph.D. (Lond.).

(b) Simla Centre—

1. Assistant Virus Pathologist . . . Shri R. N. Azad, B.Sc. (Ag.), Assoc. I.A.R.I.

CENTRAL COLLEGE OF AGRICULTURE

1. Principal . . . Dr. T. J. Mirchandani, M.Sc., Ph.D., A.I.I.Sc. (Lond.).
2. Lecturer in Agronomy . . . Dr. Jaswant Singh, B.Sc., Ph.D. (Wales).
3. „ „ Chemistry . . . Dr. W. V. B. Sundara Rao, M.Sc. (Hons.), Ph.D., Assoc. I.A.R.I. (On leave outside India).
4. „ „ Entomology . . . Dr. Sardar Singh, B.Sc., Ph.D. (Cornell).
5. „ „ Physics . . . Dr. Y. V. Kathavate, M.Sc., Ph.D.
6. „ „ Agricultural Engi-
neering. . . Shri J. R. Badola, B.Sc. (Agric. Engg.).
7. „ „ Veterinary Science . . . Dr. Gian Singh, L.V.P. (Hons.), P. G. Mukteswar.
8. „ „ Horticulture . . . Dr. G. S. Randhawa, M.Sc., M.S.A. (Toronto), Ph.D. (Mich.).
9. „ „ Mycology . . . Dr. Suryanarayana, M.Sc., Ph.D.
10. „ „ English . . . Shri S. L. Vachhar, B.A. (Hons.), M.A.

INDIAN AGRICULTURAL RESEARCH INSTITUTE DISPENSARY

1. Civil Assistant Surgeon . . . Dr. P. L. Khanna. (From 17-10-1952 to 27-12-1953).
2. Ditto . . . Dr. R. L. Handa. (From 28-12-1953).

Appendix II

Training of students and Research Workers during 1953-54

(a) List of students awarded the post-graduate diploma :—

Division of Agronomy

Name of students	Subject of thesis
1. Sri A. K. Majumdar . . .	The effects of frequency of cultivation with or without fertilizer and weeding on growth, development and yield of wheat.
2. „ R. A. Choudhury . . .	Experiment on placement of fertilizers on wheat.
3. U. Ba Khin . . .	Studies on the manurial effects on different varieties of <i>Nicotiana rustica</i> tobacco.
4. Sri S. Basu . . .	Effect of organic manures and inorganic fertilizers on the growth, development and yield of wheat.
5. „ Ajit Singh . . .	Effect of cultivation, fertilizers and methods of placement on the yield of potato.
6. „ M. R. Mangukia . . .	The effect of weeds on the growth and yield of wheat under different seed rates and different doses of nitrogen fertilizer.
7. „ N. P. Wankbede . . .	Behaviour of different varieties of American cotton and their response to sowing dates and spacings between rows.
8. „ M. S. Choudhury . . .	Optimum time of application of some nitrogenous fertilizers to wheat.
9. „ R. D. Prasad . . .	Cultural-cum-varietal-cum-manurial experiments on sugarcane.
10. „ N. K. Chopra . . .	Irrigation of wheat in relation to nitrogen and varieties.
11. „ P. L. Kapoor . . .	Cultural-cum-manurial experiment on cotton.
12. „ N. K. Shinde . . .	Fertility building value of guar.
13. „ I. R. Babu . . .	Studies on performance of cotton varieties and manuring of tobacco.
14. „ M. Alam . . .	Effect of weedicides, forms of nitrogen and its doses on sugar cane.
15. „ Y. R. Mahajan . . .	Experiment to determine the interval between the application of farmyard manure and sowing of wheat to obtain optimum yield.

Division of Botany

16. „ N. G. Prasada Rao . . .	Cytogenetical studies of pentaploid wheat hybrids.
17. „ G. Rama Rao . . .	A study of the influence of synthetic herbicides on the control of weeds and yield of wheat.
18. „ N. N. Roy . . .	Studies of the Indian collection of Maize varieties with special reference to the relationship between yield and other characters.
19. „ D. N. Misra . . .	Lodging in three varieties of wheat in relation to level and time of application of nitrogen.
20. „ M. N. Hari . . .	Studies in autotetraploids of linseed (<i>Linum usitatissimum</i>).
21. „ P. N. Ghosh . . .	Cytogenetical studies in the species and species hybrids of <i>Triticum</i> .
22. „ S. P. Singh . . .	Studies on drought resistance in wheat.

23. Sri N. K. Bajpaye . . . Inheritance studies in *Linum* species crosses.
L. marginale (A. cunn. ex. Plough).
L. usitatissimum.

Division of Chemistry

24. „ V. D. Sharma . . . Studies on some typical alkaline soil profiles of Southern India.
 25. „ B. S. Banurjee . . . Studies on some typical paddy growing soils.
 26. „ P. P. Jha . . . Studies on black soils of Kotah (Rajasthan).
 27. „ A. K. Dutta . . . Studies on the soils of Bundi (Rajasthan).
 28. „ H. C. Mehta . . . Physical and chemical properties of some soil profiles from Rann of Kutch.
 29. „ A. Wali . . . Effect of different manures and fertilizers on the biological aspects of Delhi soil and on the yield of wheat.

Division of Entomology

30. „ P. V. Rangarao . . . Temperature co-efficient of insect susceptibility to insecticides.
 31. „ M. J. Chacko . . . Superparasitism in *Trichogramma evanescens minutum* Riley (Hymenoptera: Trichogrammatidae) an egg parasites of sugarcane and maize borers in India.
 32. „ K. S. Rao . . . Effect of carriers on the toxicity of insecticides.
 33. „ O. S. Bindra . . . Studies on the epicuticle in relation to susceptibility of different instars of *Schistocerca gregaria* Forsk. to contact insecticides.
 34. „ H. S. Sangwan . . . Superparasitism in *Bracon* (*Microbracon*) *gelechiæ* Ashmd., (Braconidae: Hymenoptera), an ectophagous larval parasite of the potato tuber moth, *Gnorimoschema operculella* Zeller (Gelechiidae-Lepidoptera).
 35. „ S. S. Bhatia . . . Comparative toxicity of synthetic insecticides to some of the important pests of stored grains and their products.
 36. „ M. G. Haridas . . . Susceptibility of different stages of locusts to different stomach poisons (with special reference to the histopathology of the alimentary canal of the immature stages of *Schistocerca gregaria* Forsk.).

Division of Mycology

37. „ S. M. Gufran . . . Saltation in *Colletotrichum falcatum* Went, the causal organism of red rot of sugarcane.
 38. „ G. Rangaswami . . . Antibiotic action of *Bacillus subtilis* etc. in relation to certain fungi.
 39. „ P. Kanjansoon . . . 1. Fungus flora of stored seed of vegetable crops and pulses.
 2. *Alternaria* blight of *Zinnia elegans*.
 40. „ H. U. Joshi . . . Virus diseases of *Vinca rosea* L.
 41. „ Asharfi Jha . . . Virus diseases of chilli (*Capsicum frutescens* L.).
 42. „ J. N. Kapoor . . . *Alternaria* Leaf Spot and Fruit Rot of brinjal.

(b) Students admitted during the year :—

Agronomy

1. Bhagwant Bajirao Turkhede.
 2. Chet Ram Sharma.
 3. Chaman Lal Wadhwa.
 4. A. Venkatachari.
- Sudhir Chandra Paul.

6. Babu Lal Neema.
7. Ashwani Kumar Verma.
8. Parthasarthy Aravamudhan.
9. Yerramelli Jagarao.
10. Ishwar Chandra Mahapatra.
11. Kanti Kumar Mitra.
12. P. Kumar Bose.
13. Shankar Lal Pandey.
14. Shrawan Vithalrao Bokde.
15. Swaroop Singh.
16. Shankar Dayal Verma.
17. Sant Kumar Rana.
18. Nityananda Pathanayak.
19. Krishan Dev Puri.

Botany

20. Digamber Borgaonkar.
21. Arjan Dev Saini.
22. A. T. Natarajan.
23. Narayanrao Lukshmanrao Bhale.
24. Jogindar Singh.
25. Amarjit Singh.
26. Shah Suryakanta Shankarlal.
27. Matai Bhagu Hiranand.
28. Shambu Nath Dubey.
29. K. N. Mallana.
30. Amresh Man Pradhang.
31. K. Narasimhamurty.
32. Kuldip Bhushan Lal Jain.
33. K. Dharendra Singh.
34. C. N. Mahadik.
35. Trimbak Yeshwan Thorat.

Chemistry

36. Daulatrao Amritrao Shinde.
37. Pulimootti Koshi Thomas.
38. Gajanan Chintaman Padoley.
39. Chandra Mohan Mathur.
40. Kuppuswamy Iyenger Rajagopalan.
41. Om Parkash Dhamija.
42. Mehnga Singh Khara.
43. Deorao Vithoba Bhalkar.
44. G. Ram Chandra.

Entomology

45. Gokal Chand Sharma.
46. Jataprolu Gopalakrishna.
47. Mallampalli Ramchandrarao.

48. Siri Chand Garg.
49. Prithu Narsang Rana.
50. Turuvekere Somiah Thontadarya.
51. Baldev Prasad.

Mycology

52. Malladi Lakshmi Narayanasastri.
53. Taddi Satyanarayan Reddi.
54. Vallilath Madathil Gangadharan Nair.
55. Danesh Chandra Sharma.
56. Tek Niranjan Mehrishi.

1-Year Plant Protection Course

1. Krishan Sahai Asthana.
2. Manohar Lal Kapoor.

(c) Regular short courses :—

Short Course in Soil Survey

- | | | |
|--|---|------------------|
| <ol style="list-style-type: none"> 1. Y. P. Sood 2. B. Singh 3. J. B. Barua | } | 6 months course. |
|--|---|------------------|

Short Course in Plant Protection

- | | | |
|--|---|------------------|
| <ol style="list-style-type: none"> 1. Mahesh Babu . 2. D. S. Mullick . 3. R. R. Zevri . 4. S. K. Sen Gupta . 5. P. K. Bose . 6. D. K. Dutt . 7. R. H. Misra . 8. S. Narain Singh . | } | 3 months course. |
|--|---|------------------|

(d) Students admitted for other short course training during the year :—

Chemistry

1. S. Goswami.
2. D. V. Gaur.

Entomology

1. Vasant Rao.
2. S. P. Bose.

(e) Honorary Research workers admitted during the year :—

Botany

1. N. L. Dhawan.

Chemistry

1. O. P. Chawla.
2. Jayant Rao.
3. I. D. Dharni.
4. M. N. Sadaphal.
5. C. L. Kumar.

Entomology

1. Ved Bharat.
2. R. N. Katiyar.
3. V. Bala.
4. Saran Singh.

Appendix III

List of papers published during 1953-54.

1. Acharya, C. N. Cowdung gas plants. 'Indian Farming' (1953) N. S. Vol. 3, pp. 16-17.
2. Acharya, C. N. and Ghosh, A. B. Growth of crops in nitrogen free soil. *Proc. Ind. Sci. Congress (1954)*, Part III, p. 246.
3. Acharya, C. N. and Jain, S. P. . Nitrifiability of soil organic matter. *J. Ind. Soc. Soil Sci. (1954)*. Vol. II, pp. 43-48.
4. Acharya, C. N. and Jain, S. P. . Influence of the method of storage on the microbiological properties of soil. *Proc. 41st Ind. Sci. Cong. (1954)*, Part III, p. 246.
5. Acharya, C. N. and Jha, J. . . Studies on the building up of soil fertility by the phosphatic fertilization of legumes. Influence of berseem on the microbiological properties of soil. *J. Ind. Soc. Soil Sci. (1954)*. Vol. II, pp. 21-28.
6. Acharya, C. N., Jha, J. and Jain, S. P. Studies on the building up of soil fertility by the phosphatic fertilization of legumes—II Influence of a berseem rotation on the organic matter level of the soil. *J. Ind. Soc. Soil Sci. (1953)*, Vol. I, pp. 83-87.
7. Acharya, C. N. and Juneja, P. C. Studies on the production of combustible gas and manure from cattle dung. *Proc. 41st Ind. Sci. Cong. Session (1954)* : p. 246.
8. Azad, R. N. *Saponaria* Leaf-curl. *Ind. Phytopath.* **6** (2) : 141-142, 1953 (issued in August, 1954).
9. Banerjee, R. M. and Das, N. B. Studies on the diastatic activity of certain Indian wheats. *Ind. J. Agri. Sci. (1954)*, Vol. 24, pp. 45-49.
10. Bhaduri, P. N. and Ghose, P. N. Chromosomal biotypes in emmer wheat. *Proc. 41st Indian Science Congress Session (1954)*, Pt. 3 : 250.
11. Bhaduri, P. N. and Ghose, P. N. An improved squash technique for the study of chromosomes in cereals. *Proc. 41st Ind. Sci. Congr. Session (1954)*, pt. 3, 251.
12. Bhowmick, H. D. and Raychaudhuri, S. P. Relative merits of organic manures and inorganic fertilizers. *Proc. Natl. Instt. of Sci. of India (1953)*, Vol. 19, pp. 35-43.
13. Biswas, T. D. and Das, N. B. . . A preliminary study of amino acids in some typical Indian soils. *Commemoration Volume 60th birth day of Dr. J. N. Mukherjee (1954)*, pp. 118-126.
14. Biswas, T. D. ; Dakshinamurti, C. and Das, N. B. Studies in the carotene content of some green leafy vegetables. *Ind. J. Physiology and allied science (1953)*, Vol. 7, No. 2.
15. Capoor, S. P. Differentiation of Dolichos Enation Mosaic and Tobacco Mosaic viruses by means of cross immunization *41st Ind. Sci. Cong. Session (1954) Symposium on Plant Viruses*.
16. Chandrasekhar, M. R. ; Mathur, M. L. and Das, N. B. Rotation and fertilization as affecting the quality of wheat. *Sci. and Cult. (1953)*. Vol. 19, p. 199.
17. Chatterji, S. M. On some preservatives against Bruchid pest of stored 'mung'. *Sci. & Cul.*, **18** : 333. (1953).
18. Chatterji, S. M. On the infestation of Bruchids in milled and unmilled pulse. *Sci. & Cul.*, **19** : 305 (1953).
19. Chatterji, S. M. On the effect of humidity on some pests of stored cereals. *Ind. J. of Ent.*, **15** (4) : 327-329 (1953).

20. Chatterji, S. M. Biological notes on *Chetastriidae*: *Makheji* Mani (Hymenoptera : Trichogrammatidae), an egg parasite of *Bruchus analis* Fabr. *Ind. J. Ent.* **15** (4) : 382-83 (1953).
21. Chatterji, S. M. On a new record of a Bethyloid parasite on *Rhicopertha limitica* Fabr. *Current Science*, Feb., 1954, **23** : 59-60 (1954).
22. Chena, B. L. and Bapat, B. S. . . . Occurrence in nature of *Phylospora tennamensis* Spee., the perfect stage of Sugarcane Red Rot Organism, in India. *Ind. Phytopath.* **6** : 63-85, 1953.
23. Chena, B. L. and Bapat, B. S. . . . The occurrence in nature of *Phylospora tennamensis* Spee., the perfect stage of Sugarcane Red Rot fungus in India (Abstract). *2nd Biennial Conference of Sugarcane Research and Development Workers in Indian Union, Part I, 1954*.
24. Chena, B. L. and Bapat, B. S. . . . Investigation on the survival of the Sugarcane Red Rot fungus in the compost (Abstract). *2nd Biennial Conference of Sugarcane Research and Development Workers in Indian Union, Part I, 1954*.
25. Chena, B. L. and Narayan, T. K. . . Investigations on the survival of *Colletotrichum falcatum* Went. in soil. *Ind. Phytopath.* **5** : (2) 152-157 (Dec., 1953).
26. Chena, B. L. and Srivastava, D. N. . . . The Perithecial stage of *Colletotrichum falcatum* Went in India. *Ind. Phytopath.* **5** : 153-160, 1952 (Dec., 1953).
27. Chena, B. L. and Srivastava, D. N. . . . Verification of *Colletotrichum falcatum* Went, the causal organism of Red Rot of sugarcane (Abstract). *2nd Biennial Conference of Sugarcane Research and Development Workers in the Indian Union, Part I, 1954*.
28. Chakrabarti, P. M. Brief notes on some grasses and legumes for soil conservation in India. *Jr. Soil. & Water Cons. in India*, (22) : 67-69, 1954.
29. Daksinamurti, C. and Mehta, S. C. . . . Influence of the Arding material on the Cathode Enrichment layer. *Proc. 41st Ind. Sci. Cong. Session (1954)*.
30. Das, C. B. and Raychandhuri, S. P. . . . A probable strain of Tomato Aucuba Mosaic Virus. *Ind. Phytopath.* **6** : 116-122, 1953.
31. Das, N. B. and Biswas, T. D. . . . Identification of amino acids in wheat, gluten and mung seed kernel. *Sci. & Cul.* (1953), Vol. 19, p. 158.
32. Dasai, S. V. and Sen, A. . . . Studies on the characteristics of saline and alkaline patches in the soils of Pusa. *Ind. J. Agri. Sci.* (1953), Vol. 23, pp. 187-202.
33. Dasai, S. V., Sundara Rao, W. V. B. and Tejwani, K. G. . . . A lysimeter study of crop rotations Part I.—Crop yields and soil productivity : *Ind. J. Agri. Sci.* **23** : 243.
34. Dhangra, P. K. and Das, N. B. . . . Chemical composition and nutritive value of Indian pulses. *Proc. Ind. Sci. Congr. (1954)*. Part III, p. 249.
35. Deshpande, B. B. and Deswan, L. L. . . . A prostrate mutant in pigeon-pea (*Cajanus cajan* (L.) Mill sp., a possible soil conservation plant. *Ind. J. Genet. & Pl. Breed* **12** : 50-51.
36. Ganguly, B. D. and Redwan, L. L. . . . Possibilities of growing ratoon crop of paddy and increasing its yield under irrigated conditions. *Sci. & Cul.* 19(7) : 350-351, 1952.
37. Ghosh, A. B. A note on the yield and composition of sannhemp green manure when grown alone and with phosphatic fertilizer. *Proc. 41st Ind. Sci. Congr. (1954)*. Part III, p. 242.
38. Gulati, K. C. Improvements in or relating to the preparation of terpenyl alcohols and ether. *Indian Patent No. 48429*.
39. Gulati, K. C. and Chatterji, B. G. . . . Improvements in or relating to the preparation of terpenyl monochloro acetates. *Indian Patent No. 47115*.
40. Hingorani, M. K. and Adiy, S. K. . . . Factors influencing bacterial Soft Rot of Potatoes. *Ind. Phytopath.* **6** (2) : 110-115, 1953.
41. Idnani, M. A. The value of conservation of urine as manure. *Ind. J. Agric. Sci.* (1953), Vol. 28, pp. 55-64.
42. Joshi, A. B. and Haridas, M. W. . . . Chromosome number of *Abelmoschus tuberosus* Pal et Singh a species related to the cultivated *Bhindi*—*Curr. Sci.* **13** : 1-6.

43. Kartha, A. R. S. ; Sethi, A. S. & Gulati, K. C. Rapid estimation of yield and iodine value of oil in small samples of oil seeds. *Proc. 41st Ind. Sci. Congr. (1954), Part, III*, pp. 249-250.
44. Khan, A. R. Observation on the traditional lore of tillage. *Sci. & Cul.*, 19(9) : 1954.
45. Khan, A. R. and Kapoor, P. C. Studies on the cultivation and manuring of cotton. *Proc. 41st Session of Ind. Sci. Congr. (1954)*, Part III, p. 236.
46. Khan, A. R. and Majumdar, A. K. Studies on the effect of frequency of cultivation with and without the fertilizer weedicide on the growth, development and yield of wheat. *Proc. 41st Session of Ind. Sci. Congr. (1954)*, Part III, p. 236.
47. Khan, A. R. and Mathur, B. P. Studies on tillage II. Effect of depth of cultivation on the yield of maize and wheat. *J. Agri. Sci.* XXII, Pt. II, 127-132, 1954.
48. Khan, A. R. and Mathur, B. P. Relative effect of different forms of green manuring on the yield of wheat. *Allahabad Farmer* 27(2) : 72-75, 1953.
49. Khan, A. R. and Mathur, B. P. Effect of turning under sunnhemp (green manure) with and without fertilizers on the yield. *Allahabad Farmer* 27(2) : 68-71, 1954.
50. Khan, A. R. and Misra, K. P. Studies on the effect of variation in the depth of cultivation with varying doses of Nitrogen and Phosphate on the yield of sugarcane varieties. *Proc. 2nd Biennial Conf. Sug. & Dev. Workers, Jullundur, Pt. I*, 23-24, 1954.
51. Khan, A. R. ; Misra, K. P. and Masood Alam. Studies on relative efficiency of different forms and doses of Nitrogen with and without weedicides on the yield of sugarcane. *Proc. 2nd Biennial Conf. Sug. & Dev. Workers, Jullundur, Pt. I*, 29-30, 1954.
52. Mehta, S. C. and Daskhinamurti, C. Extration and estimation of traces of nicotine. *Proc. 41st Ind. Sci. Congr. (1954)*.
53. Mirchandani, T. J. and Khan, A. R. Green-manuring. *ICAR Review Series No. 6* : 1-37, 1953.
54. Mookherjee, P. B. Studies on the phytotoxicity on the modern organic insecticides. *Proc. 41st Ind. Sci. Congr. Pt. III*, p. 260 (1954).
55. Mookherjee, P. B. Phytotoxicity in cotton plants due to DDT spraying. *Curr. Sci.* 23 (2) : 56 (1954).
56. Mukherji, S. Present systematic position of *Pyrilla* spp. in India. *Proc. Ind. Sci. Congr. 41st Session Curr. Sci.* 23(6) : 193-194 (1954).
57. Mukherji, S. Genital structure of *Bruchus* (*Laria*) *albopubeans*. *J. Ind. Ent.* 16(1) (1954).
58. Mukherji, S. Genital structures of *Anobiidae* and *Ptinidae*. *Rec. Ind. Mus. Part I*.
59. Narayanan, E. S. Seasonal Pests of Crops : The Root, Stem and Top Borers of sugarcane and the methods of their control. *Indian Farming.* 3(1) : 8-11 (1953).
60. Narayanan, E. S. Seasonal pests of Crops : The Red Pumpkin Beetle and its control. *Ibid.* 3(2), 8-9 (1953).
61. Narayanan, E. S. Seasonal Pests of Crops : *Chilo zonellus* Swinh. *Hieroglyphus nigrorepletus* Bol. two serious pests of maize and jowar. *Ibid.* 3(3) : 8-9 (1953).
62. Narayanan, E. S. Seasonal Pests of Crops : Fruit Fly Pests of Orchards and Kitchen Gardens. *Ibid.*, 3(4) : 8-11 (1953).
63. Narayanan, E. S. Seasonal Pests of Crops : Some Major Insect Pests of Rice and their control. *Ibid.*, 3(5) : 8-13 (1953).
64. Narayanan, E. S. Seasonal Pests of Crops : The red-hairy caterpillar, *Amsacta moorei* Butler and its control. *Ibid.*, 3(7) : 8-9 (1953).

65. Narayanan, E. S. . . . Seasonal Pests of Crops: Insect Pests of Stored grain and their control. *Ind. Farming*, 3(7): 8-13 (1953).
66. Narayanan, E. S. . . . Seasonal Pests of Crops: The Mustard Saw-fly, *Athalia proxima* Klug., a pest in the nurseries of the cabbage family. *Ibid.*, 3(9): 8-9 (1953).
67. Narayanan, E. S. . . . Seasonal Pests of Crops: Sugarcane Leaf Hopper *Pyrilla perpusilla* Walker. *Ibid.*, 3(9): (1953).
68. Narayanan, E. S. . . . Seasonal Pests of Crops: The Painted Bug, *Bagrada crucifera-rum* Kirk., *Ibid.*, 3(10): 8-9 (1954).
69. Narayanan, E. S. . . . Seasonal Pests of Crops: The Mustard Aphid, *Rhopalosiphum pseudobrassicæ* (Davis). *Ibid.*, 3(11): 8-9 (1954).
70. Narayanan, E. S. . . . Seasonal Pests of Crops: The Greasy cutworm—*Agrotia vosilon* Rott., a serious pest of Rabi crops. *Ibid.*, 3(12): 8-10 (1954).
71. Narayanan, E. S.; Angalet, G. W.; Subha Rao, B. R. and D'Souza, G. I. The effect of refrigeration on the pupae of *Bracon brevincornis* Wesm. on the pigmentation of the adult. *Nature*, 173: 503 (1954).
72. Narayanan, E. S. and Chacko, M. J. Superparasitism in *Trichogramma evanescens minutum* Riley. *Proc. Ind. Sci. Congr. 41st Session* (1954).
73. Narayanan, E. S. and Chatterji, S. M. On a new Macropterous species of *Triphleps* (Hymenoptera. Heteroptera: Anthocoridae) predaceous on storage pests in India. *Proc. Zool. Soc. Bengal.*, 6(2): 121-123 (1953).
74. Narayanan, E. S. and Kundan Lal. Studies on Indian Ichneumonidae. Part I. Sub-family Pimplinae, Tribes Polysphinctini and Theroniini. *Ibid.*, 15(4): 310-326 (1953).
75. Narayanan, E. S. and Kundan Lal. Studies on Chalcid egg parasites of *Pyrilla* sp. Part I. Bionomics of *Tetrastichus pyrrillae* Craw., *Aegenispsia pyrrillae* Mani and *Chilonerus pyrrillae* Mani. *Ind. J. Ent.*, 15(3): 173-179 (1953).
76. Narayanan, E. S. and Mookherjee, P. B. The present position of the Sugarcane top borer, *Scirpophaga nivell* Fabr. in India and possibilities of its control by means of its natural enemies. *Proc. 2nd Biennial Conf. of Sug. Res. & Dev. Workers, Jullundur*, p. 53(1954).
77. Narayanan, E. S. and Rattan Lal. A short review of recorded information on the control of termites damaging crops in India, along with results of recent experiment in Delhi. *Ind. J. Ent.* 14(1): 21-30.
78. Narayanan, E. S. and Samuel, C. K. "The Phadka grasshopper and its control". Leaflet No. 2 *Agric. Deptt., Delhi*. (1954).
79. Narayanan, E. S. and Samuel, C. K. "The Mustard Aphid and its control." Leaflet No. 3. *Ibid.*, (1954).
80. Narayanan, E. S. and Samuel, C. K. "The Bagrada Pest and its control." Leaflet No. 4. *Ibid.*, (1954).
81. Narayanan, E. S. and Samuel, C. K. "The Red Pumpkin Beetle or Lal Bhoondi." Leaflet No. 5. *Ibid.*, (1954).
82. Narayanan, E. S. and Sangwan, H. S. Superparasitism in *Bracon gelechiae* Ashmd. *Proc. Ind. Sci. Cong. 41st Session* (1954).
83. Narayanan, E. S. and Subha Rao, B. R. The Anatomy of the Reproductive Organs of *Bracon gelechiae* Ashmead and the mode of oviposition. *Proc. Ind. Sci. Cong. 41st Session* (1954).
84. Narayani, T. K. and Pathanian, P. S. *Physalis peruviana* L.—A new host of Tobacco Leaf Curl virus. *Ind. Phytopath.* 6(2): 143-145, 1953.
85. Nath, Narinder and Das, N. B. Effect of monthly cut on the chemical composition of some indigenous grasses. *Ind. J. Vet. Sci.* (1953). Vol. 23, pp. 185-204.
86. Nath, Narinder and Das, N. B. Effect of growth stage on the chemical composition of some indigenous grasses. *Ind. J. Vet. Sci.* (1953), Vol. 22, 43-51.

87. Nimgade, N. M. and Sen, A. Recovery of molybdenum from laboratory wastes in the estimation of P_2O_5 in soils, fertilizers and plants.
88. Pal, B. P. Some new and noteworthy wheats. *Indian Farming* (N. S.) 3 : 18-19, 32.
89. Pal, B. P. ; Vasudeva, R. S. and Kohli, S. P. Breeding Rust Resistant Hill wheats in India. *Special Bulletin of the I.C.A.R.*
90. Parthasarathy, N. The use of induced autopolyploidy in plant breeding. *Ind. J. Genet. & Pl. Breed.* 13 : 1-6 (1953).
91. Pradhan, S. and Bindra, O. S. Relation between changes in susceptibility and various factors connected with successive instars of the Desert locust. *Curr. Sci.*, 22 : 380-81 (1953).
92. Pradhan, S. and Govindan, M. Effect of temperature on the degree of susceptibility of insects to fumigation. *Ind. J. Ent.*, 15 (4) : 262-75 (1953).
93. Pradhan, S. and Jotwani, M. G. Studies on some aspect of bioassay of stomach poisons. *Proc. Ind. Acad. Sci.* 39 (2) : 37-43 (1954).
94. Pradhan, S. and Peshwani, K. M. Studies for the construction of Biometer for *Trichogramma evanescens minutum* Riley-Parasite of sugarcane stem and root borers—*Proc. 2nd. Biennial Conf. of Sug. Res. & Dev. Workers in Indian Union* (1954).
95. Pradhan, S. and Satpathy, J. M. Bioassay of insecticides. II. Comparative toxicity of some important insecticides to *Oxycaenus lactus* Kirby and *Rhopalosiphum pseudobrassicae*. *Ind. J. Ent.* 15 (4) : 297-98 (1953).
96. Raheja, P. C. Double cropping. *I. C. A. R. Review Series No. 6* : 1-37.
97. Raheja, P. C. Nature of Growth Correlation in Sugarcane. *Proc. Second Biennial Conf. of S. R. & D. Workers. Pt. I.*, p. 77, 1954.
98. Raheja, P. C. and Misra, G. N. Growth of ratoon crop as affected by spacing between plants *Proc. Second Biennial Conf. of S. R. & D. Workers. Pt. I.* 67, 1954.
99. Raheja, P. C. and Oberai, S. R. Why practise mixed cropping ? *Ind. Farming, III*, (3), 1953 :
100. Rajan, S. S. Studies in Polyploidy breeding ; part I. Effectiveness of the mass pedigree system of selection in the improvement of seed setting in the colchicine induced auto-tetraploids of toria. *Proc. 41st Ind. Sci. Cong. Session* (1954). Part III, 3 : 250.
101. Ramanujam, S. and Parthasarathy, N. Auto-polyploidy—a review. *Ind. J. Genet. & Pl. Breed* 13 : 53-82.
102. Ramiah, R. V. Threshing wheat by a tractor and disc-harrow. *Ind. Farming* Vol. III, No. 4, July, 1953, page 14-15.
103. Ramiah, R. V. Hand operated markers for transplanting rice. *Ind. Farming*, Vol. III, No. 5, August, 1953, pp. 14-15.
104. Ramiah, R. V. "Japan shows the way". *The Hindu-Farming Supplement*, dated 22-7-1953.
105. Ramiah, R. V. Buyers' Guide for Indian Agricultural Implements. (Booklet). *I.C.A.R. Review Series No. 5*, August, 1953.
106. Rattan Lal Notes on the effect of temperature on the developmental stages of *Anopheles Subpictus* grassii and *Anopheles stephensi* Liston. *Ind. J. Ent.* 15 (2) : 97-106.
107. Rattan Lal and Gupta, S. B. L. Morphology of immature stages of *Sphaerophoria Scutellaris* Fabr. (Syrphidae Diptera) with notes on its biology. *Ind. J. Ent.* 15 (3) : 207-18.
108. Rattan Lal & Menon, Ram Das Catalogue of Indian Insects Part 27—Isoptera. *Government of India's Publications, Delhi.*
109. Raychaudhuri, S. P. Soil surveys and planning. *J. Soil & Water Cons. in India* (1953), Vol. I, pp. 7-10.
110. Raychaudhuri, S. P. Agricultural practices in ancient India—a preliminary study. *I.C.A.R. Review Series* (1953) No. 4.

111. Raychaudhuri, S. P. ; Ooman, P. K. and Kamath, M. B. Comparative study of the available P_2O_5 in various types of Indian soils as determined by different methods. *Proc. 41st Ind. Sci. Cong. (1954)*, Part III, p. 241.
112. Raychaudhuri, S. P. and Sharma, V. D. Studies on saline and alkaline soils of India. Part I, Some typical profiles from Bombay and Madras States. *Proc. 41st Ind. Sci. Cong. (1954)*, Part III, p. 240.
113. Raychaudhuri, S. P. and Subbiah, B. V. Soils tests in India for determining the fertilizer needs. *Sindri News (1953)*, Vol. I, No. 11.
114. Raychaudhuri, S. P. and Subbiah, B. V. Utilization of rock phosphate, bone meal, nitre earth gypsum and non-edible cakes as manures. *41st. Proc. Ind. Sci. Cong. (1954)*—Symposium on indigenous manuring materials.
115. Raychaudhuri, S. P. and Subbiah, B. V. Phosphate manuring of legumes and its role in the building up of soil fertility of Indian soils. *Transactions of the Joint Commissions II & IV of the International Society of Soil Science, 1953*.
116. Raychaudhuri, S. P. and Tripathi, R. D. Studies on the saline soils of Delhi State II. Some typical profiles of the Jamna Khaddar area (South). *J. Agri. Sci. (1953)*, Vol. 23, pp. 213-222.
117. Samuel, C. K. and Chetterji, S. M. Studies on varietal resistance and susceptibility of Jowar (*Andropogon sorghum*) to storage pests in India. *Ind. J. Ent.*, **15**(3) : 225-239.
118. Sen, A. . . . Some soils of the inner Himalayas. *Sci. & Cul. (1953)*, Vol. 19, pp. 234-237.
119. Sen, A. . . . Studies on the characteristics of saline and alkaline patches in the soils of Karnal Farm., *Ind. J. Agri. Sci. (1953)*, Vol. 23, pp. 203-212.
120. Sen, A. . . . Studies on Azotobacter from tank silts. *Proc. 41st Ind. Sci. Cong. (1954)*, Part III, pp. 241-242.
121. Sen, A. . . . A study on the development of salinity in cultivated soils. *Ind. J. Agri. Sci. (1954)*, Vol. 24, pp. 23-43.
122. Sen, A. . . . Fixation of nitrogen from ammonium sulphate by Indian soils. *Ind. J. Agri. Sci. (1954)*, Vol. 24, pp. 111-126.
123. Sen, A. & Asija, G. L. . . . A study of the action of tank silt on soil. *Ind. J. Agri. Sci. (1953)*, Vol. 23, pp. 223-231.
124. Sen, A. and Asija, G. L. . . . Action of tank silt on soil. *Ind. J. Agri. Sci. (1954)*, Vol. 24, 51-63.
125. Sen, A. ; Rewari, R. B. and Vyas, N. D. Production of combustible gas from cane mollasses. *Sci. & Cul. (1954)*, Vol. 19, pp. 562-564.
126. Sen, N. and Satyanarayana, K. V. S. Studies on the soils of Rann of Kutch. *Quart. J. Geol. Min. & Met., 1953*, pp. 51-62.
127. Sen, S. and Pal, B. P. . . . Response of certain varieties of wheat to different fertility levels. *Ind. J. Agri. Sci.* **23** : 1-26 (1953).
128. Sethi, A. S. ; Kartha, A. R. S. and Gulati, K. C. Rapid estimation of yield and iodine value of oil in small samples of oil seeds. *Curr. Sci. (1953)*, Vol. 22, p. 266.
129. Singh, H. B. and Bagchandani, P. M. Genetics in leaf mutation in gram (*Cicer arietinum* L.) *Ind. J. Genet. & Pl. Breed.* **13** : 106-109. (1953).
130. Singh, H. B. . . . Grow more sweet potatoes. *Indian Farming*, N. S. 3 : 24-25.
131. Singh, Rattan ; Biswas, T. D. and Das, N. B. Studies on the nicotinic acid content of wheat as influenced by locality. *Proc. 41st. Ind. Sci. Cong. (1954)*, Part III, p. 249.
132. Srinivasan, T. R. ; Chatterjee, B. G. and Gulati, K. C. Nicotine sulphate from tobacco waste. *J. Ind. Chem. Soc. (Ind. News Ed.) (1953)*, Vol. 16, p. 143.
133. Sundara Rao, W. V. B. and Ishwaran, V. Studies on nitrogen fixation by azotobacter. *Proc. 41st Ind. Sci. Cong. (1954)*, Part III, p. 242.
134. Sundara Rao, W. V. B. and Seth, S. P. Indicator plant studies using tomato (*Lycopersicon esculentum*). Part II. *Proc. 41st Ind. Sci. Cong. (1954)*, Part III, p. 243.

135. Sundara Rao, W. V. B. ; Desai, S. V. and Tejwani, K. G. A lysimeter study of crop rotations. Part II—The quality and composition of crops. *Ind. J. Agri. Sci.* **23** : 255.
136. Sundara Rao, W. V. B ; Desai, S. V. and Tejwani, K. G. A comparative study of some methods of assessing mineral deficiencies in the soil. *J. Ind. Soc. Soil Science* **1** : 121.
137. Suryanarayana, D. . . . Infection caused by the oospores of *Sclerospora sorghi* (Kulk.). *Pers. Ind. Phytopath.* **7(1)** : 1953.
138. Tamhane, R. V. . . . Land and Irrigation. *Ind. Farming* (1953).
139. Tamhane, R. V. and Kaul, S. N. Physico-chemical studies of black soils of Jabalpur. *Proc. 41st Ind. Sci. Cong. (1954), Part III*, p. 245.
140. Tamhane, R. V. ; Shome, K. B. and Raychaudhuri, S. P. Soils of arid and semi-arid zones in India. I. Delhi and Ajmer. *J. Ind. Soc. Soil Sci.* (1953), Vol. I., pp. 105-112.
141. Tamhane, R. V. ; Satyanarayana, K. V. S. and Sen, A. A note on the soils of Andaman Islands. *Proc. 41st Ind. Sci. Cong. (1954), Part III*, p. 245.
142. Venkatraman, T. V. and Subba Rao, B. E. The mechanism of oviposition in *stenobracon deesae* (Cam.) *Proc. R. Ent. Soc. London. Ser. A.*, **29** : 1-8.
143. Vasudeva, R. S. . . . Progress in Mycology and Plant Pathology in the last quarter of a century. *Silver Jubilee Volume of I.C.A.R.*
144. Vasudeva, R. S. . . . Fungi of Economic Importance. *Wealth of India., a Dictionary of Indian Raw Materials and Industrial Products.*
145. Vasudeva, R. S. and Azad, R. N. Investigations on potato diseases and productions of disease-free potatoes in India. *Empire Journal of Experimental Agriculture*, **20** : No. 80.
146. Vasudeva, R. S. and Chakravarthi, B. P. Antibiotic action of *Bacillus subtilis* in relation to certain parasitic fungi with special reference to *Alternaria Solani*. *Annals of Applied Biology* (accepted for publication).
147. Vasudeva, R. S. ; Jain, A. C. and Nema, K. G. Investigations of the inhibitory action of *Bacillus subtilis* on *Fusarium udum* Butl. the fungus causing wilt of Pigeon-pea (*Cajanus cajan* L.) (Millsp.). *Ann. App. Biology*, **39** : 229-238, 1952.
148. Vasudeva, R. S. ; Joshi, L. M. and Lele, V. C. Susceptibility of some grasses to control Rusts. *Indian Phytopath* **6** : 39-46, 1953.
149. Vasudeva, R. S. and Govindaswamy, C. V. Studies on the effect of associated soil Microflora of *Fusarium udum* Butl. the fungus causing wilt of Pigeon-pea *Cajanus cajan* (L) pathogenecity. *Ann. App. Bio.* **40** : 1953.
150. Verma, R. D. . . . Potatoes in plenty. *Indian Farming*, **III(7)** : 22, 23 & 27, 1953.
151. Vyas, N. D. . . . Effect of some indigenous phosphates on the fixation of atmospheric nitrogen through pea. *J. Ind. Soc. Soil Sci.* (1953), Vol. I, pp. 41-46.
152. Vyas, N. D. . . . A modified method of utilizing sannhemp for manurial purposes *Proc. 41st Ind. Sci. Cong. (1954), Part III*, p. 248.
153. Vyas, N. D. and Desai, J. R. Effect of different doses of superphosphate on the fixation of atmospheric nitrogen through pea. *J. Ind. Soc. Soil Sci.* (1953), Vol. I, pp. 32-40.
154. Vyas, N. D. and Farooque, M. Effect of Singhbhum Phosphate on soil microflora and crops. *Proc. 41st Ind. Sci. Cong. (1954), Part III*, p. 247.
155. Vyas, N. D. and Jha, K. K. . Role of micro-organisms in increasing the yield of crops and their nitrogen and phosphoric acid uptake. *Proc. 41st Ind. Sci. Cong. (1954), Part III*, pp. 247-248.

